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USER DOCUMENTATION

EOD-LARSYS

EARTH OBSERVATIONS DIVISION VERSION OF THE LABORATORY FOR APPLICATIONS OF REMOTE SENSING SYSTEM

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For

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SPACE AND LIFE SCIENCES DIRECTORATE

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

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EARTH OBSERVATIONS DIVISION VERSION OF THE LABORATORY FOR APPLICATIONS OF REMOTE SENSING SYSTEM

Job Order 71-695

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TECHNICAL REPORT INDEX/ABSTRACT
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13. ABSTRACT

This document is a user's manual for the Earth Observations Division version of the Laboratory for Applications of Remote Sensing System. It sets out the procedures for using system processors in the analysis of multispectral scanner image data, both independently and in conjunction with other processors. System tape and Fastrand files and card input are described in detail, along with restrictions and diagnostic messages for the use of various processors.

The system is operational on the Univac 1108, EXEC 2, located in JSC building 12.

14. SUBJECT TERMS

Classification	Feature selection	Mapping
Clustering	Histograms	Scatter plots
Displays	Landsat imagery	Transformations

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PREFACE

The Earth Observations Division version of the Laboratory for Applications of Remote Sensing System reflects the efforts of many researchers and programmers over a period of several years. Special assistance and consultation were provided to the authors by K. Baker and A. H. Feiveson of the Earth Observations Division of the National Aeronautics and Space Administration, Lyndon B. Johnson Space Center and N. J. Clinton, W. G. Eppler, T. C. Minter, and J. A. Quirein of Lockheed Electronics Company, Inc.

Some of the software incorporated in this version of the system includes program modules developed for other systems. Two routines from the Algorithm Simulation Test and Evaluation Program were provided by M. T. Li of Lockheed Electronics Company, Inc., and J. K. Daly of the TRW Systems Group. In addition, specific routines were provided by A. H. Feiveson to compute thresholds for the classification-by-thresholding algorithm.

CONTENTS

Section	Page

Section | Page

Section | Page

Section		Page

Section		Page

TABLES

FIGURES

Figure | Page

Figure		Page

1. INTRODUCTION

For several years, the Earth Observations Division (EOD) of the National Aeronautics and Space Administration (NASA), Lyndon B. Johnson Space Center (JSC), has supported research for the development of techniques to be used in processing remotely sensed imagery data obtained from the multispectral scanner (MSS) placed aboard various aircraft and satellites. One of the earliest operational computer systems to use pattern recognition techniques in the analysis of these data was developed at Purdue University's Laboratory for Applications of Remote Sensing (LARS). The earliest version of the LARS system (LARSYS) was converted in 1970 to a batch program for execution on the Univac 1108 EXEC 2 system at NASA/JSC (ref. 1).

The computer system described in this document originated from this early version of the LARSYS. However, since 1970, personnel of the EOD, Lockheed Electronics Company, Inc. (LEC), and other EOD support contractors have made many modifications and improvements to the Univac 1108 version of the LARSYS; thus, new techniques have been developed and programmed to perform additional functions in the evaluation of the data.

Although the basic structure of the system remains the same, a large portion of it has been reprogrammed. Modifications to existing techniques and the addition of new techniques have expanded the capabilities of the system. The current version is called the EOD-LARSYS.

The purposes of this document are to define the capabilities and limitations of the system and to provide the user with the information needed to execute the program and obtain the output desired. It is assumed throughout the document that the user

is familiar with the terminology and the pattern recognition techniques involved. No attempt is made to assist the user in the analysis of data output by the system.

2. GENERAL SYSTEM DESCRIPTION

The EOD-LARSYS is a batch processing program operational on the Univac 1108 EXEC 2 system at NASA/JSC. The system is composed of a system monitor and a set of processors, each of which performs a specific function in the analysis of MSS imagery data. Linkage between processors is accomplished by the use of files or card decks. The execution of a particular batch job may begin or end with any processor, provided the appropriate files or card decks are furnished.

Two pattern recognition classification schemes are provided by the system. One, the supervised classification algorithm known as the maximum likelihood classifier, is embodied in the CLASSIFY processor (ref. 2). The other, an unsupervised classification or clustering algorithm, is embodied in the Iterative Self-Organizing Clustering System (ISOCLS) processor (ref. 3). ISOCLS, along with other processors, may be used to "train" the maximum likelihood classifier or to display the results of classification.

Having obtained an MSS image data tape (DATAPE) in one of the allowable formats (see section 3.2), the data analyst must train the classifier. The maximum likelihood classification algorithm is based on the assumption that the samples within a given class are distributed according to a multivariate normal probability density function. Such distribution is specified completely in terms of a mean vector and a covariance matrix, which must be computed from known samples of the class being represented. This implies that the data analyst must have some prior knowledge (i.e., ground-truth information) of specific areas within the MSS image. Using this ground truth, the analyst must identify training samples for computation of statistics. To aid the analyst in locating these training samples, the histogram (HIST) and GRAYMAP processors are provided.

The HIST processor provides a histogram of data values from the MSS image for use by the GRAYMAP processor. HIST may also be used independently to provide the analyst with information on the distribution of data values within specific user-defined blocks (or fields) of the image. The mean, standard deviation, and range of data within each user-defined field are standard outputs from the HIST processor for each requested channel. Histogram plots may be obtained optionally. With the histogram information, a file (HISFIL) is written automatically for the GRAYMAP processor.

The GRAYMAP processor provides the analyst with a pictorial gray-scale map of any channel of the MSS image for use in obtaining training field coordinates. The map is labeled by sample and scan-line numbers. From this map, the analyst may locate the fields within the image for which he has ground-truth data. Having identified the fields, coordinates (sample and scan-line numbers at each vertex) must be noted for defining the fields to the statistics (STAT) or ISOCLS processor. Since the output device used to make the line printer map has fewer symbols than the 256 gray shades allowed by the MSS data resolution, a reduction in the number of gray shades must be made. The map produced by GRAYMAP is printed with up to 16 different symbols. The analyst may define the symbols and corresponding range from the histogram. The latter method allows equal activity for each of 10 standard symbols chosen to produce a wide range of gray shades.

The coordinates for the training fields may be input to either the STAT or ISOCLS processor for computation of statistics for the classifier. Both processors save the statistics and training field information on a file (SAVTAP, section 4.1) for use in other processors.

In using the STAT processor, the user must group training fields into statistically similar subclasses. Subclasses may be grouped further into classes. For example, three statistically similar subclasses of spring wheat, winter wheat, and harvested wheat may be grouped into one wheat class. Statistics for each subclass are maintained on the SAVTAP file, along with the class grouping. Class groupings are maintained simply for convenience in defining categories in the CLASSIFY processor and for performance reports by the DISPLAY processor. The analyst may obtain the following output for each training field and/or subclass.

- Mean vector
- Covariance matrix
- Correlation coefficient
- Histogram plots
- Spectral plots

In using the ISOCLS processor, the user must group training fields into classes. The clustering process breaks the class data into statistically similar subclasses (clusters). Subclasses are given names by taking the first three characters of the class name and three digits indicating the number of the subclass within the class. Again, the statistics for each subclass are saved on the SAVTAP file for use in other processors. ISOCLS is an iterative self-organizing clustering procedure which uses the measure of absolute (L1) distance from a picture element (pixel) to the cluster center to determine the similarity of pixels. At each iteration the user may obtain a cluster summary and map. Optionally, a cluster image data tape (MAPFIL) may be output in either LARSYS II or Universal format (appendixes A and B, respectively).

Using the transform statistics (TRSTAT) processor, the statistics on the SAVTAP file output by the processor STAT or ISOCLS are transformed according to

$$\left.\begin{aligned} \mu' &= A\mu + b \\ K' &= AKA^T \end{aligned}\right\} \qquad (2\text{-}1)$$

where

μ' = transformed means

A = a matrix

μ = means from SAVTAP file

b = a vector

K' = transformed covariance matrix

K = covariance matrix from SAVTAP file

A^T = transpose of matrix A

The transformed statistics are output as a new file on SAVTAP.

Before proceeding to classification of the MSS image, it may be desirable to reduce the dimensionality of the data vectors by selecting a smaller set of channels or a linear combination of the channels which maximizes some class separability measure. The SELECT processor (ref. 4) provides this capability. In order to compute the value of the separability measures, the statistics calculated using the STAT or ISOCLS processors must be made available to the SELECT processor either by card deck, tape, or Fastrand file. The SELECT processor allows the analyst to work with subsets of the statistics on the file, if he desires. Subsets of the statistics are indicated by the CHANNELS and SUBCLASS control cards, which are defined further in section 10.4.3.

In addition, the statistics for two or more subclasses may be grouped together and considered as one subclass. Grouping the statistics for two or more subclasses is equivalent to going back through the STAT processor and combining all training fields for those subclasses being grouped into one subclass. The grouping option is exercised via the GROUP control card defined in section 10.4.3. The subsets and groupings of the statistics provided to the SELECT processor for computation are used only in SELECT and are not passed on to other processors.

The SELECT processor also allows the analyst to evaluate a given set of channels using one of three different separability measures or to select the best set of channels (k) out of the total channels (n) based on one of these separability measures. The three separability measures provided are:

a. Weighted average interclass divergence

b. Weighted average transformed divergence

c. Weighted average Bhattacharyya distance

To select the best set of k out of n channels, the analyst may use either the Without Replacement Search Procedure or the Exhaustive Search Procedure. A third procedure will find k linear combinations of n measurements which extremize a given separability measure. This procedure, known as the Davidon-Fletcher-Powell Procedure, outputs the linear combinations in matrix form. All the procedures and equations for separability measures referred to above are discussed in detail in reference 5.

After the SELECT processor has determined the subset or the linear combination of channels which maximizes subclass separability, the supervised classification of the imagery data is performed by the

CLASSIFY processor. The options available in SELECT for grouping and selecting subsets of the SAVTAP file are also available in CLASSIFY.

However, once the statistics for classification have been specified, the classes and subclasses are renumbered and referred to in the DISPLAY processor by the new numbers.

The CLASSIFY processor allows the user to group classes previously defined by the STAT or ISOCLS processor into categories for the sum-of-densities classification. When a category is defined (by class names), all subclasses in each class are assigned to the category. The density function for category i, $P_i(x)$, is the sum of densities for all subclasses in the category; that is,

$$P_i(x) = \sum_{j=1}^{k_i} p_j(x) \tag{2-2}$$

where

p_j = the probability density function for subclass j

k_i = the number of subclasses in category i

(Note: More detailed equations are given in section 11.)

Pixel x is assigned to category i if $P_i(x) > P_k(x)$ for all categories $k \neq i$. Pixel x is further assigned to subclass j if (1) j belongs to category i and (2) $p_j(x) > p_k(x)$ for all subclasses k, $k \neq j$, and k belongs to category i.

Obviously a one-to-one correspondence between categories and subclasses reduces the above equation to:

$$P_i(x) = p_j(x) \tag{2-3}$$

When this is the case, the amount of computation required for classification can be greatly reduced by the use of thresholds. CLASSIFY then has two procedures for classification which use this computational reduction to advantage. The sum-of-densities rule is used only when categories are defined by the user. Otherwise, the classification-by-thresholding procedure detailed in reference 5 is used.

The CLASSIFY processor writes a file (MAPTAP, section 4.4 and appendix C) containing the subclass number and confidence level for each pixel classified; the training fields and statistics for the classes and subclasses actually used in classification; and the correspondence between categories, classes, and subclasses.

The DISPLAY processor accepts the file output by CLASSIFY and generates a line-printer map of the classified data, along with several performance tables. In the map, each subclass has a symbol associated with it. A threshold option is provided for the analyst to print no symbol (blank) for samples classified with a confidence level less than some specified threshold value.

Performance summaries are provided on subclass, class, and category levels for pixels within each classified field, training field, and test field which are input to the DISPLAY processor. The training or test field performance summaries may be obtained by fields and/or classes. The DISPLAY processor also provides optional output of a classification map (MAPFIL) on tape in either Universal or LARSYS II format.

The data-transformation (DATA-TR) processor allows the analyst to use the linear transformation matrix computed by SELECT to create a new image data tape (TRFORM). Since the matrix is computed to extremize subclass separability, the k linear combinations out of n channels represented by the matrix produce better

class contrast when the image is displayed; that is, on the Data Analysis Station (DAS). In addition, the best linear combination of the data can be used to enhance the image.

The TRFORM tape may be output in either the LARSYS II or Universal format.

The NDHIST processor performs an n-dimensional histogram of areas on the MSS data tape (DATAPE), for which the user wishes to create scatter plots. The fields may be histogrammed on a class, subclass, or per-field basis. A line-printer summary of the fields, the number of data vectors in each field, and the number of unique data vectors histogrammed is given.

Optionally, if a scatter plot of a classified or clustered area is requested, a classification or cluster image data tape (MAPFIL) from the DISPLAY or ISOCLS processor must be input to NDHIST. If this option is exercised, the field or fields input to this processor and their order of input must be the same as those input to CLASSIFY or ISOCLS.

Information such as the field, cluster or subclass number, the frequency of occurrence, and color code for each histogrammed radiance vector is written on the n-dimensional histogram (NDIM) file.

The SCTRPL processor reads the NDIM file, and a two-axis color-coded spectral plot (PLOTAP) is output in the Universal format. The background for the plot may be black or white.

If more than two channels were histogrammed by the NDHIST processor, the data vector is reduced to two components by

$$y' = Ax + b \qquad (2\text{-}4)$$

where

y' = transformed image

A = matrix

x = data vector

b = bias vector

The location on the scatter plot for each vector in the NDIM file is determined by its radiance values (if only two channels were histogrammed) or by two linear combinations of radiance values (if more than two channels were histogrammed).

The color for the pixel is assigned by

- Original radiance values
- Mean value of the subclass or cluster to which the pixel was assigned during classification or clustering
- Mean value of the test or training field from which the pixel was extracted
- User-defined colors
- Color extraction from a different pass when using multi-registered Landsat data.

Optionally, for pixel color assignment, the SAVTAP file created by STAT or ISOCLS may be input.

Optionally, a line-printer pixel frequency or log of pixel frequency (base 2) plot is given. The plot is printed with up to 16 different symbols.

Figure 2-1 is a flow diagram of the EOD-LARSYS.

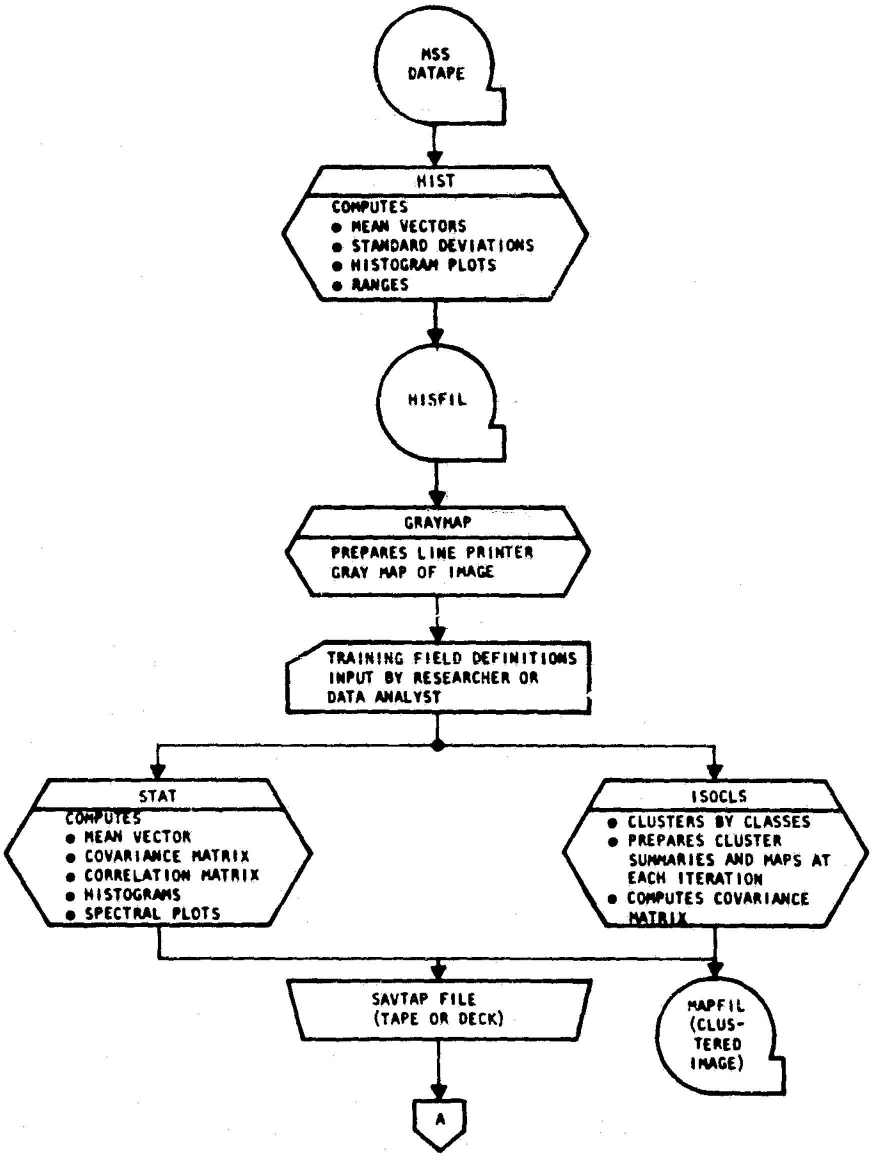


Figure 2-1.— Flow diagram of the EOD-LARSYS.

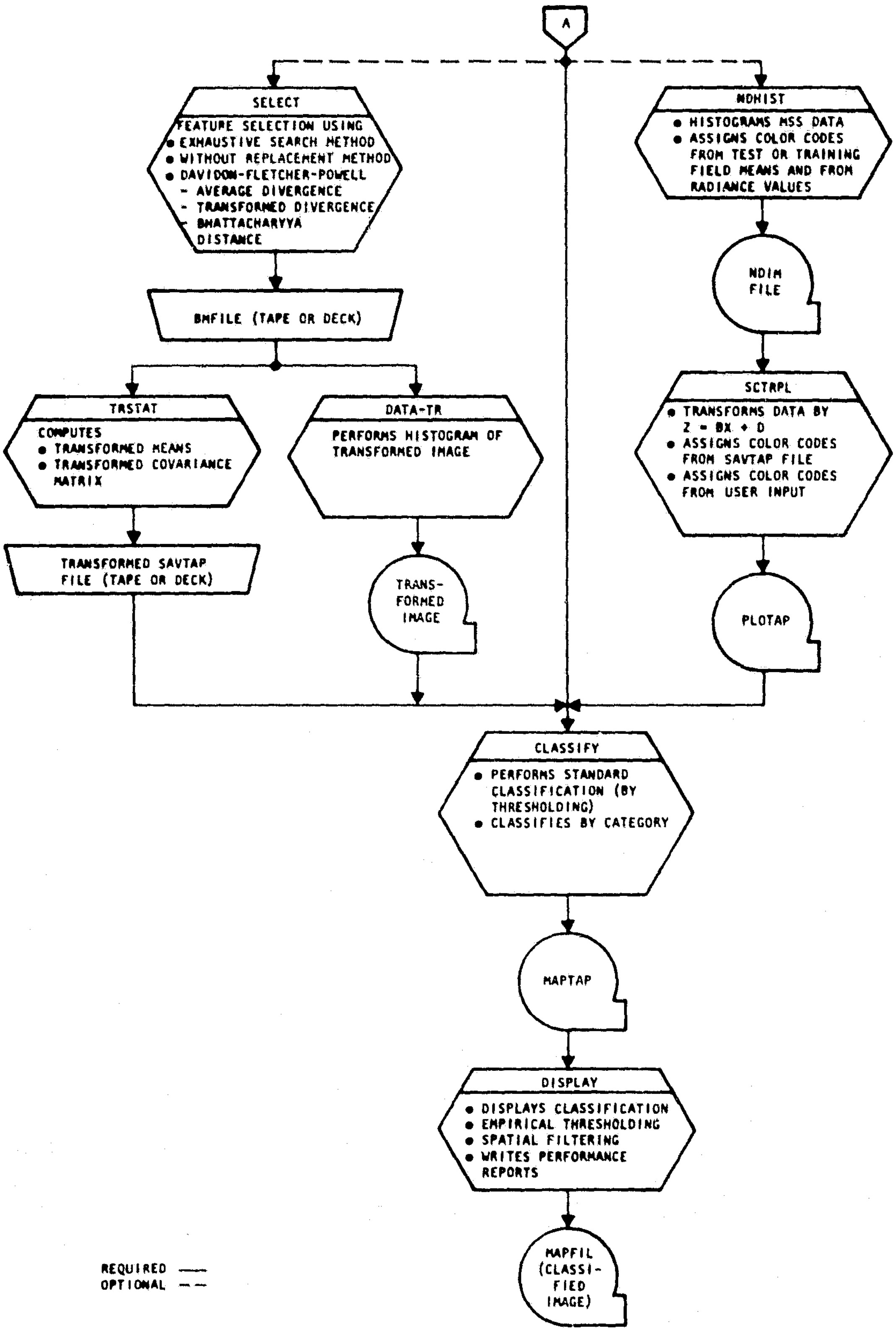


Figure 2-1.– Concluded.

3. SYSTEM INPUT/OUTPUT FORMATS

3.1 CARD INPUT/OUTPUT

Card input to and output from the system must be one of the following types.

3.1.1 PROCESSOR CARDS

Processor cards identify the processor that is to be executed. The system monitor routine calls the appropriate processor, which initiates the loading of all routines used by the processor. The processor card is always a $ symbol followed by the processor name and must always be punched left justified beginning in column 1. No blanks are allowed. The $ symbol and the first five characters are the unique processor identification used by the system monitor routine.

Below is a list of all processor cards recognized by the system, along with the section in which each processor is described.

$HIST	Section 6
$GRAYMAP	Section 7
$STAT	Section 8
$ISOCLS	Section 9
$SELECT	Section 10
$CLASSIFY	Section 11
$DISPLAY	Section 12
$DATA-TR	Section 13
$TRSTAT	Section 14
$NDHIST	Section 15
$SCTRPL	Section 16
$EXIT	Execution terminates when this card is encountered.

3.1.2 CONTROL CARDS

Each processor has its own set of control cards which allow the user to exercise various options in the particular processor or to change the default value assigned to certain parameters in the system. These cards must immediately follow a processor card. The control cards are identified by a keyword in columns 1 through 10 of the card. Only the first six characters are used for testing. In columns 11 through 72, the parameter values or options are indicated. These columns are free form, blanks are ignored (unless of legitimate parameter value), and multiparameter values or options are separated by commas. Columns 73 through 80 of the card are not used. With the exceptions of the *END*, $END*, and in some cases the STATFILE cards, control cards may occur in any order. (The STATFILE control card exception is noted in the section for the appropriate processor.) If the list of parameter values for a given keyword is too long for one card, the remaining values can be input on another card with the same keyword. (The continuation of a CATEGORY control card is slightly different; see section 11, table 11-1.) In every processor, the *END* control card indicates the end of a set of control cards, and the $END* indicates the end of field definition card input.

3.1.3 CLASS, SUBCLASS, AND FIELD DEFINITIONS

A field is a specific block of data to be extracted from the input MSS data tape (DATAPE) and processed. It is defined by a sample increment, a line increment, and from 1 to 10 vertices. Optionally, the user may associate a name with each field. The alphanumeric field description is located in columns 1 through 6. In columns 11 through 72, sample and line increments are separated by a comma and enclosed in parentheses. A comma separates the increments and each of the following vertices. The vertices must be arranged in clockwise order. Sample and line numbers which describe a vertex are separated by a comma and enclosed in parentheses. The sample number must be given first for each vertex.

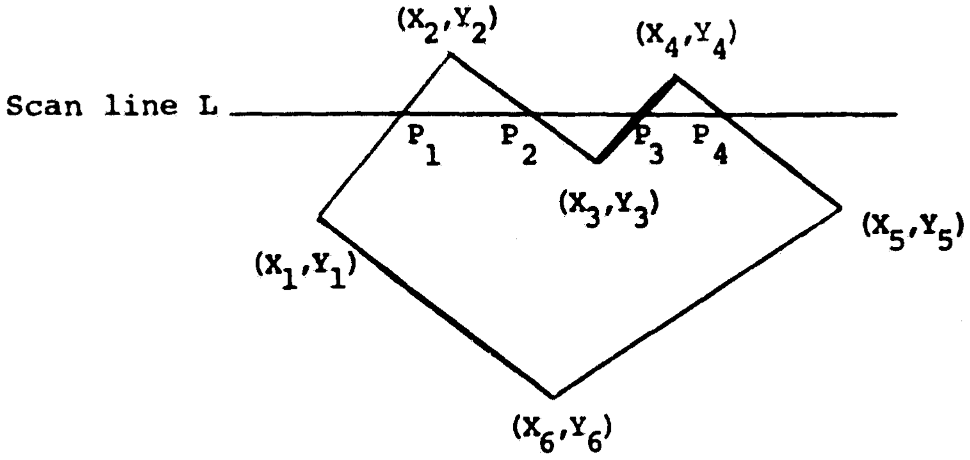
More than one card may be used to describe a field. An asterisk occurring after a vertex indicates a continuation card is to be read beginning in column 11. A vertex must be completed on a card and cannot be split between two cards. The numbers which describe the increments and vertices must be integers.

It is the user's responsibility to ascertain that all defined fields are within the bounds of the MSS image. In determining which pixels belong in a particular field, the EOD-LARSYS examines the pixel intercepts of each scan line with each side of the field. The pixel intercept X, with the scan line L and the side defined by vertices (X_1,Y_1) and (X_2,Y_2), is calculated by the equation:

$$X = \frac{(L - Y_1)(X_2 - X_1)}{(Y_2 - Y_1)} + X_1 \tag{3-1}$$

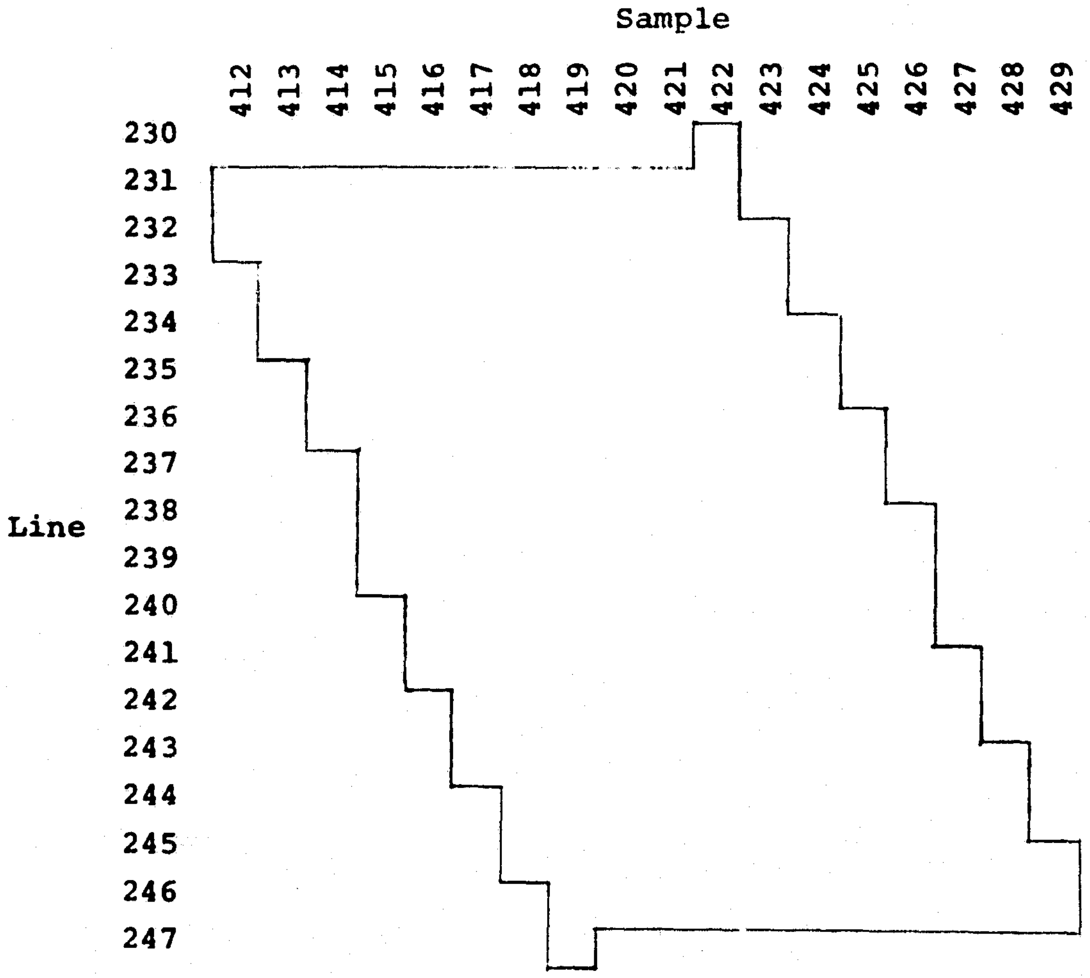
The value of X is computed as a floating-point number; however, the actual pixel intercept must be an integer number. Therefore, if the fractional part of X is greater than one-half, the pixel intercept is the next higher integer number. If the fractional part of X is less than one-half, the pixel intercept will be the next lower integer number. When the fractional part of X is exactly one-half, the integer pixel intercept depends on the direction of movement from the point (X_1,Y_1) to (X_2,Y_2). If Y_1 is less than Y_2, the pixel intercept is the next higher integer. If Y_1 is greater than Y_2, the pixel intercept is the next lower integer number.

After all pixel intercepts for a given scan line have been determined, the intercepts are taken in pairs and all pixels between and including the pair of intercepts are included in the field. In the following example for scan line L, all pixels between and including P_1 and P_4 are included, and all pixels between and including P_3 and P_4 are included.



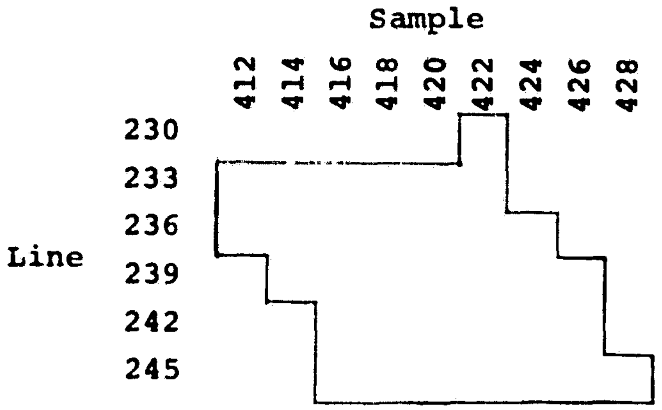
The following three examples describe field definition cards and the fields they describe. In example 1, the sample and line increments are equal to 1 for field F1, and there are four vertices.

F1 (1,1),(412,231),(422,230),(429,246),(419,247)



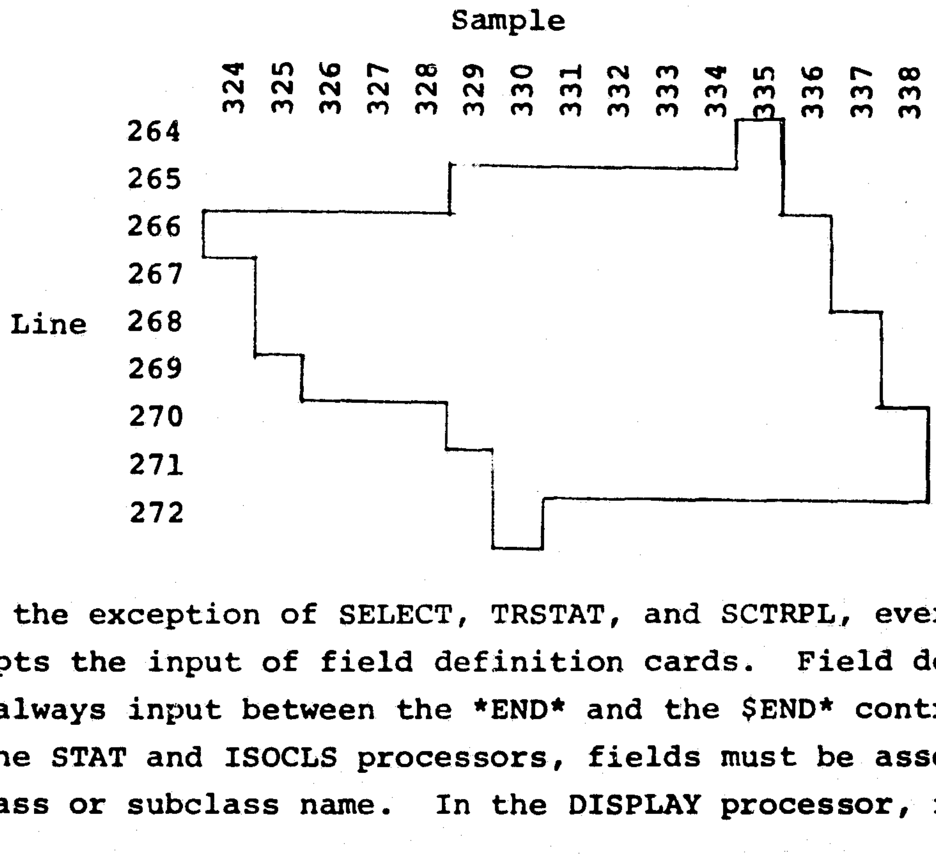
In example 2, the field F2 has the same vertices as F1; however, the sample increment is 2 and the line increment is 3.

F2 (2,3),(412,231),(422,230),(429,246),(419,247)



In example 3, the sample and line increments for field W187 are equal to 1, and there are six vertices.

W187 (1,1),(324,266),(335,264),(338,271),
(330,272),(329,269),(326,269)



With the exception of SELECT, TRSTAT, and SCTRPL, every processor accepts the input of field definition cards. Field definitions are always input between the *END* and the $END* control cards. In the STAT and ISOCLS processors, fields must be associated with a class or subclass name. In the DISPLAY processor, fields may

be test fields or designated fields. In the NDHIST processor, fields are associated with class, subclass, test or training, or any user-defined field.

The fields defined in STAT and ISOCLS are called training fields, and the data within these fields are used for computing statistics. Training fields are grouped into subclasses, and subclasses are further grouped into classes, using the STAT processor. In ISOCLS, training fields are grouped into classes, and the clustering procedure breaks the class data into subclasses (clusters). To allow for these groupings, cards bearing a class name and a subclass name are necessary.

A class name card has the keyword CLASSNAME beginning in column 1 and the alphanumeric name of the class left justified in columns 11 through 16 of the card. Blanks should not be embedded in the class or subclass names.

A subclass name card has the keyword SUBCLASS beginning in column 1 and the alphanumeric name of the class left justified in columns 11 through 16 of the card.

In STAT, a CLASSNAME card must immediately follow the *END* control card. The CLASSNAME card is followed by one or more SUBCLASS cards, each of which must be followed by one or more field definition cards. See the example for STAT (section 8.4.4).

In ISOCLS, a CLASSNAME card must immediately follow the *END* control card. The CLASSNAME card is immediately followed by one or more field definition cards. The data from the fields associated with a given class name are clustered as one data set. The class is broken into subclasses (clusters) which do not have field boundaries. So, even though statistics are

computed on a subclass level, training fields cannot be associated with subclasses in ISOCLS. See the example for ISOCLS (section 9.5.4).

In DISPLAY, test fields (if input) must be identified by a previously defined class or subclass name. When associated with classes, a CLASSNAME card should immediately follow the *END* control card. Test fields for that class should follow immediately. When associated with subclasses, a SUBCLASS card should immediately follow the *END* card, followed by the test fields for that subclass.

Designated fields are the other type of field input to DISPLAY. Fields may be designated "unidentifiable" or "other." For input of designated fields, a card with the keyword DESIGNATE beginning in column 1 and the keyword OTHER or UNIDENTIFIABLE beginning in column 11 must precede the field definition cards. See section 12.4.4 for sample input of test and designated fields.

3.1.4 SPECIAL SYSTEM DECKS

The card decks described in this section are special decks normally output from one processor to be used at some future time for input to another processor. However, if the user can obtain all of the information needed for any of the special card decks from some other source, such information may be input directly to the processor if the formats described in this section are followed.

These decks are always included in the deck setup with the control cards for the particular processor. The first card of each deck acts as a keyword which initiates the input of the deck.

Upon input of any of these special system card decks, a corresponding internal file is written with the information read from cards. The file is then used to transfer the data from one processor to another. It is not necessary to input the same deck to more than one processor in the same run.

3.1.4.1 Module STAT Deck

The module STAT deck is optional output from the STAT, ISOCLS, and TRSTAT processors. It contains either the statistics (mean vectors and covariance matrices) for all the subclasses input to STAT or for clusters computed by ISOCLS or the transformed statistics for all subclasses or clusters input to TRSTAT. These statistics are needed in the computation of the probability density function in CLASSIFY and the computation of separability measures in SELECT.

This deck also contains all the training field boundaries, the class and subclass numbers to which the training fields belong, the class and subclass names, the number of subclasses in each class, and the number of points in each subclass or cluster. By defining the required training fields in STAT, the user has absolute control over the data samples which will define a subclass from the MSS data tape (DATAPE). Every data sample occurring in any one of the training fields defined by a particular subclass is used in computing the mean vector and covariance matrix for that subclass.

In the clustering processor ISOCLS, the user has no control over the specific samples which comprise a cluster. The processor determines which data samples are used in computing the mean vector and covariance matrix for each cluster. Because of the desirability of using these cluster statistics in other processors, the ISOCLS processor punches the deck and creates a file in the same format as the STAT processor. Training fields are associated with classes rather than subclasses. Clusters are

given a six-character name. The first three characters are the first three characters of the class name associated with the cluster, and the last three characters are digits. The digits for the subclasses are in sequential order.

When the module STAT deck is input to the CLASSIFY or SELECT processor, the user may request subsets of the statistics to be used for classification or channel selection via the CHANNELS and SUBCLASS control cards in both processors. Subclasses are numbered as they were input to STAT, and clusters are numbered as they were created in ISOCLS. The channels are numbered as they occur on the MSS data tape (DATAPE). To select a subset of the statistics in the module STAT deck, the user should indicate by number the subclasses and/or channels he wishes to use. (Unless the user has previous knowledge of the number of clusters in the module STAT deck, he or she cannot accurately select a subset of the clusters when executing ISOCLS back to back with another processor.)

The first card in the module STAT deck acts as a control card, with the keyword MODULE initializing the input of the remainder of the deck. The entire deck is composed of the card types listed below. All integers should be right justified in the specified field, and alphanumeric characters should be left justified in the specified field.

- Card type 1 — Keyword MODULE in columns 1 through 6.
- Card type 2 — Number of classes, subclasses, channels, fields, and vertices for training fields.

Columns	Type/format	Definition
7—10	Integer/I4	Number of training classes from STAT or ISOCLS
19—20	Integer/I2	Number of training subclasses from STAT (clusters from ISOCLS)

Columns	Type/format	Definition
29–30	Integer/I2	Number of channels used in computation of statistics
38–40	Integer/I3	Number of training fields input to STAT or ISOCLS
49–52	Integer/I4	Number of vertices in all the training fields

- Card type 3 — Actual channels used in computation of statistics.

Columns	Type/format	Definition
11–12	Integer/I2	Channel 1
13–14	Integer/I2	Channel 2
15–16	Integer/I2	Channel 3
⋮	⋮	⋮
69–70	Integer/I2	Channel 30

- Card type 4 — Training field information: The first card of the set.[1]

Columns	Type/format	Definition
1–6	Alphanumeric/A6	Field name
11–12	Integer/I2	Number of the class associated with this field
21–22	Integer/I2	Number of the subclass associated with this field input to STAT (Since ISOCLS associates fields with classes, ISOCLS dummies this information by setting it equal to zero.)

[1]Card types 4 and 5 define a training field. To complete the set of information for one training field, one card of type 4 and one or two cards of type 5 are required. The number of card sets is determined by the number of training fields.

Columns	Type/format	Definition
31—32	Integer/I2	Number of vertices for this field, including closure point

- Card type 5 — Vertices for the training field: Up to 10 vertices plus the closure point are allowable for each training field, 7 vertices per card with coordinates ordered (sample, line). The coordinates are listed in a clockwise manner, with the coordinate having the smallest sample number listed first.[2]

Columns	Type/format	Definition
11—15	Integer/I5	Sample number of first vertex
16—20	Integer/I5	Line number of first vertex
21—25	Integer/I5	Sample number of second vertex
26—30	Integer/I5	Line number of second vertex
⋮	⋮	⋮
76—80	Integer/I5	Line number of the seventh vertex

- Card type 6 — Class names, nine names per card, left justified in field: The number of cards is determined by the number of classes.

Columns	Type/format	Definition
11—16	Alphanumeric/A6	Six-character class name for first class
19—24	Alphanumeric/A6	Six-character class name for second class

[2]Card types 4 and 5 define a training field. To complete the set of information for one training field, one card of type 4 and one or two cards of type 5 are required. The number of card sets is determined by the number of training fields.

Columns	Type/format	Definition
27–32	Alphanumeric/A6	Six-character class name for third class
⋮	⋮	⋮
75–80		Six-character class name for the ninth class

- Card type 7 – Number of subclasses in each class, 24 per card: The number of cards is determined by the number of subclasses.

Columns	Type/format	Definition
9–10	Integer/I2	Number of subclasses in first class
12–13	Integer/I2	Number of subclasses in second class
15–16	Integer/I2	Number of subclasses in third class
⋮	⋮	⋮
78–79	Integer/I2	Number of subclasses in 24th class

- Card type 8 – Subclass names, 10 per card: The number of cards is determined by the number of subclasses.

Columns	Type/format	Definition
9–14	Alphanumeric/A6	Six-character subclass name for first subclass
16–21	Alphanumeric/A6	Six-character subclass name for second subclass
23–28	Alphanumeric/A6	Six-character subclass name for third subclass
⋮	⋮	⋮
72–77	Alphanumeric/A6	Six-character subclass name for 10th subclass

To complete the set of statistics for one subclass, the following three types of cards are grouped together. The number of sets of cards is determined by the number of subclasses.

- Card type 9 – Number of points in this subclass.

Columns	Type/format	Definition
13–20	Integer/I8	Number of points in this subclass

- Card type 10 – Mean vector for this subclass, five values per card: The number of cards is determined by the number of channels.

Columns	Type/format	Definition
6–20	Real/E15.8	Mean for first channel for this subclass
21–35	Real/E15.8	Mean for second channel for this subclass
36–50	Real/E15.8	Mean for third channel for this subclass
51–65	Real/E15.8	Mean for fourth channel for this subclass
66–80	Real/E15.8	Mean for fifth channel for this subclass

- Card type 11 – Covariance matrix for this subclass: Only the lower triangular portion of the matrix is punched; the number of values input for this matrix is equal to (number of channels) × (number of channels + 1)/2. Five values are punched on each card in the order indicated.

$$\begin{bmatrix} 1 & & & & & & \\ 2 & 3 & & & & & \\ 4 & 5 & 6 & & & & \\ 7 & 8 & 9 & 10 & & & \\ - & - & - & - & - & & \\ - & - & - & - & - & - & \\ - & - & - & - & - & - & - \end{bmatrix}$$

Columns	Type/format	Definition
6–20	Real/E15.8	Element 1 of matrix
21–35	Real/E15.8	Element 2 of matrix
36–50	Real/E15.8	Element 3 of matrix
51–65	Real/E15.8	Element 4 of matrix
66–80	Real/E15.8	Element 5 of matrix

3.1.4.2 B-Matrix Deck

This deck is an optional output of the SELECT processor when the Davidon-Fletcher-Powell Procedure is used. The deck contains a transformation matrix which extremizes a given separability measure for the subclasses being used. The matrix is optimized using the Davidon-Fletcher-Powell Procedure. The linear transformation of the original measurements can be used in the CLASSIFY, SCTRPL, TRSTAT, or DATA-TR procedure to reduce the dimensionality of the data and/or statistics.

The B-matrix deck, or corresponding file, is an optional input to SELECT, SCTRPL, and CLASSIFY and a required input to DATA-TR and TRSTAT (see A-MATRIX control card in section 14.4.3). When input to SELECT, the matrix is used to evaluate a specific separability measure or it is used as a first guess for the Davidon-Fletcher-Powell Procedure, depending on the user's request. When input to CLASSIFY, classification is performed using the linear transformation. When input to SCTRPL, the dimension of the data from the MSS data tape (DATAPE) is reduced to two linear combinations. When input to TRSTAT, a new file containing the transformed statistics is created on SAVTAP. The DATA-TR processor uses the matrix to create a new image tape with the reduced dimensionality.

The keyword B-MATRIX on a control card indicates that the B-matrix is being input. Since the matrix may be on cards or file, the parameter CARDS or FILE must be punched on the same card in columns 11 through 72. The entire card deck is defined below by card types.

- Card type 1 — The keyword B-MATRIX in columns 1 through 10 and CARDS in columns 11 through 72 initialize input of the card deck.

- Card type 2 — One card of this type.

Columns	Type/format	Definition
6–7	Integer/I2	Number of linear combinations.
13–14	Integer/I2	Number of channels.
18–80	Integer/30I2	The remainder of this card lists by number the channels for which the matrix was computed; e.g., columns 18 through 19, first channel, etc., for a maximum of 30 channels right justified in the field.

- Card type 3 — The number of these cards is determined by the size of the matrix. The values are input by column as indicated below, five values per card.

  B(k,n), k = linear combinations; n = channels

$$B = \begin{bmatrix} 1 & (k+1) & \cdots & [nk-(k-1)] \\ 2 & (k+2) & \cdots & [nk-(k-2)] \\ 3 & (k+3) & \cdots & [nk-(k-3)] \\ \vdots & \vdots & & \vdots \\ k & 2k & & nk \end{bmatrix}$$

Columns	Type/format	Definition
6–20	Real/E15.8	Element 1 of matrix
21–35	Real/E15.8	Element 2 of matrix
36–50	Real/E15.8	Element 3 of matrix
51–65	Real/E15.8	Element 4 of matrix
66–80	Real/E15.8	Element 5 of matrix (Continued on next card)

3.1.4.3 Cluster Means Deck

This deck is an optional input to the clustering processor ISOCLS. It may be used to initialize the clustering process by estimating cluster centers (means). The means can be taken from the module STAT deck (see section 3.1.4.1) punched by either TRSTAT, STAT, ISOCLS, or the user. Means may be input for up to 30 channels for each cluster center, and a subset of the channels to be used may be indicated on the CHANNELS control card.

The keyword MEANS in the control cards for ISOCLS indicates initial cluster means are being input. Since the means may be on cards or from a file, the keyword CARDS or FILE must be punched on the same card in columns 11 through 72. If on cards, CARDS initializes input of the cluster means deck which must immediately follow. The format for the entire card deck is indicated below.

- Card type 1 – Control card keyword MEANS is left justified in columns 1 through 5. The keyword CARDS in columns 11 through 72 initializes input of the card deck.

- Card type 2 — Number of clusters and channels.

Columns	Type/format	Definition
6–10	Integer/I5	Number of initial clusters for which means are provided
25–30	Integer/I5	Number of channels for which means are provided

- Card type 3 — Actual channels used in computation of means.

Columns	Type/format	Definition
6–7	Integer/I2	Channel 1
8–9	Integer/I2	Channel 2
10–11	Integer/I2	Channel 3
⋮	⋮	⋮
64–65	Integer/I2	Channel 30

- Card type 4 — Mean vectors for the initial clusters: These cards are in the same format as the means cards (card type 10) in the module STAT deck. The first mean for each cluster always begins on a new card. The number of cards depends on the number of channels and the number of clusters. Five values are placed on each card.

Columns	Type/format	Definition
6–20	Real/E15.8	Mean for channel 1
21–35	Real/E15.8	Mean for channel 2
36–50	Real/E15.8	Mean for channel 3
51–65	Real/E15.8	Mean for channel 4
66–80	Real/E15.8	Mean for channel 5 (Continued on consecutive cards of the same format)

3.2 MSS IMAGE DATA TAPES

Every processor except SELECT, DISPLAY, TRSTAT, and SCTRPL requires the input of an MSS data tape (DATAPE). The tape assignment defaults to logical unit C (Fortran unit 3), but the user may assign any unit available by input of the DATAFILE control card. For details, see the file assignment chart in section 4 and the control card section for each processor. The tape may be in either the LARSYS II (or III) format or the Universal format. These formats are defined in appendixes A and B, respectively.

The control card DATAFILE allows the user to communicate the file number of the MSS data tape (DATAPE) to be processed and the logical unit assignment. This is optional input to every processor that requires the MSS data tape. The first file of the tape will be processed unless otherwise specified by the DATAFILE control card. In executing the same and/or different processors back to back, the DATAFILE control card may be input only to the first processor executed if the same file and logical unit are to be used throughout the execution. For example,

```
$HIST                              [File 2 of the MSS data tape
DATAFILE  UNIT=3,FILE=2            (DATAPE) assigned to unit C is
:  (Other control cards)           processed by GRAYMAP as well as
*END*                              HIST.]
(Field definition)
$END*
$GRAYMAP
CHANNELS   5,6
*END*
(Field definitions)
$END*
```

The user should be aware of the following Univac 1108 EXEC 2 system options in assigning an MSS data. A tape is always assigned to a seven-track drive unless the user requests in

writing that the operator assign the tape to a nine-track drive. If the user's tape is in fact nine track, he must inform the operator on NASA/JSC form 588, which he submits with the computer run. In addition, the Univac ASG card in the deck setup must have the N-option punched on it. Since most nine-track tapes will be coming from a source other than the Univac system, the A-option, which allows frame-count errors, should be punched on the ASG card as well. This option should also be used on seven-track tapes from sources other than the Univac computer. For example,

```
@NA ASG C=(number of nine-track data tape from source other than
          Univac)
@A  ASG C=(number of seven-track data tape from source other than
          Univac)
```

NOTE: @ is the Univac control punch. It is a 7-8 multipunch in column 1 of the card.

4. SYSTEM INTERNAL FILES

The files described in this section are used internally by the system to pass information between processors. It is the user's responsibility to assign the necessary files for his particular job. On the Univac 1108 EXEC 2 system, files are assigned in the runstream with the ASG system command.

For example, to assign logical units A and B to Fastrand, the following commands are used.

```
@ ASG A
@ ASG B      or     @ ASG A,B
```

To assign logical unit B to tape, the following command is used.

```
@ ASG B=(tape number)
```

When a required file is not assigned in the runstream or dynamically by the program, the EXEC 2 system will default the assignment to the FH432 drum.

Since the FH432 drum is the highest speed input/output device available, the EOD-LARSYS system uses it for random access scratch input/output. If the user fails to assign one of the files indicated below to Fastrand or tape, the file will be written on the FH432 drum and will probably be destroyed by some later scratch input/output.

4.1 STATISTICS FILE (SAVTAP, UNIT A)

This file must be assigned to either Fastrand or tape whenever one or more of the processors STAT, SELECT, CLASSIFY, ISOCLS, NDHIST, SCTRPL, TRSTAT, or DATA-TR are executed. One file is written on this unit for each execution of STAT, TRSTAT, or ISOCLS

or for input of a module STAT deck to some other processor. The file contains the same information as itemized in section 3.1.4.1 for the module STAT deck.

Multiple files may be written on a single tape and accessed by using the STATFILE control card. This control card communicates the file number for positioning the tape and the logical unit assignment. The first file is always assumed unless otherwise specified by the user, and the unit assignment assumes logical unit A (Fortran unit 1) unless otherwise specified by the STATFILE control card. In executing several processors back to back and in referencing the same file, only one STATFILE control card need be submitted. If different file numbers are to be referenced during one execution, then the file number may be changed from one processor to the next by input of the STATFILE control card to each processor. For example,

```
$STAT
STATFILE  UNIT=1,FILE=2
(Other control cards)
*END*
(Class, subclass, and field definitions)
$END*
$CLASSIFY
*END*
(Fields to be classified)
$END*
```

The STAT processor will write the training statistics for this run on file 2 of the SAVTAP file (unit A). (The system files, their logical units, and assignments are set out in table 4-1.) CLASSIFY will use all of the statistics on file 2 of the tape for classification.

The following example shows assignments for back-to-back executions of STAT, ISOCLS, and SELECT.

```
$STAT
STATFILE  UNIT=1,FILE=2
(Other control cards)
*END*
(Class, subclass, and field definitions)
$END*
$ISOCLS
STATFILE  UNIT=1,FILE=3
(Other control cards)
*END*
(Class and field definitions)
$END*
$SELECT
STATFILE  UNIT=1,FILE=2
BEST      4
*END*
$END*
```

STAT will write on file 2 of the tape assigned to unit A, ISOCLS will write on file 3 of the same tape, and SELECT will go back to file 2 of unit A for the statistics computed by STAT.

4.2 B-MATRIX FILE (BMFILE, UNIT H)

The BMFILE contains the transformation matrix which corresponds to the B-matrix deck (section 3.1.4.2). The deck or file is an optional input to SELECT, SCTRPL, and CLASSIFY and a required input to DATA-TR and TRSTAT. When the card deck is input to any of these processors, this file is automatically written. The B-matrix is computed by the SELECT processor and automatically output to the file when the Davidon-Fletcher-Powell Procedure is executed.

The file must be assigned to Fastrand or tape.

4.3 ONE-DIMENSIONAL HISTOGRAM FILE (HISFIL, UNIT K)

On logical unit K, the HIST processor creates the HISFIL file, which is used by the GRAYMAP processor. The file should be assigned to tape or Fastrand.

4.4 CLASSIFICATION MAP FILE (MAPTAP, UNIT B)

The MAPTAP file (appendix C) must be assigned to either Fastrand or tape when the CLASSIFY and DISPLAY processors are executed. The file, which is output by CLASSIFY, contains the statistics actually used in the classification, the training field information, and all of the classification results.

It is suggested that this file be assigned to tape and saved when CLASSIFY is executed. This will allow the user to make several runs of DISPLAY without classifying every time.

4.5 N-DIMENSIONAL HISTOGRAM FILE (NDIM, UNIT D)

The NDHIST processor writes the NDIM file to be used as an interface to the SCTRPL processor. The tape default assignment is unit D, but the user may assign any available unit. (See file assignment chart, table 4-1.) The NDIM format is defined in appendix D.

4.6 TRANSFORMED STATISTICS FILE (SAVTAP, UNIT A)

The TRSTAT processor writes the transformed statistics on the SAVTAP file. (See section 4.1 for further information.)

4.7 SCRATCH FILES

The EOD-LARSYS uses the available high-speed FH432 and FH1782 drums for scratch input/output. SELECT, ISOCLS, DISPLAY, NDHIST, and SCTRPL use the scratch input/output files.

TABLE 4-1.– FILE ASSIGNMENTS FOR PROCESSORS

Processor	Logical unit (internal file name)									
	A (SAVTAP)	B (MAPTAP)	C (DATAPE)	D (NDIM)	E (PLOTAP)	H (BMFILE)	K (HISFIL)	L (TRFORM)	N (MAPFIL)	Unassigned (scratch)
HIST			Tape				Tape or Fastrand			
GRAYMAP			Tape				Tape or Fastrand			
STAT	Tape or Fastrand		Tape							
ISOCLS	Tape or Fastrand		Tape						9-track tape	FH432 FH1782
SELECT	Tape or Fastrand					Tape or Fastrand				FH432 FH1782
CLASSIFY	Tape or Fastrand	Tape or Fastrand	Tape			Tape or Fastrand				
DISPLAY		Tape or Fastrand							9-track tape	FH432 FH1782
DATA-TR	Tape or Fastrand		Tape			Tape or Fastrand		Tape		
TRSTAT	Tape or Fastrand									
NDHIST			Tape	Tape or Fastrand					Tape or Fastrand	FH432 FH1782
SCTRPL	Tape or Fastrand			Tape or Fastrand	9-track tape	Tape or Fastrand				FH432 FH1782

5. SYSTEM OUTPUT TAPE FILES

5.1 MAP TAPE (MAPFIL, UNIT N)

On logical unit N (Fortran unit 16) the DISPLAY processor optionally outputs a multifile data tape (MAPFIL) containing the subclass number to which each corresponding pixel was assigned during classification by CLASSIFY. Also, on logical unit N, the ISOCLS processor outputs a MAPFIL containing either the cluster number (OPTION CLUSTER control card) or the mean vector to which each corresponding pixel was assigned during clustering. A color key containing the color code for each cluster is given for the mean vectors. The color codes optionally may be ordered according to the cluster number or to greenness (OPTION ORDER control card). (See section 9.5.3, table 9-1, for ISOCLS control cards.)

The results of the classification/clustering may be displayed on the Passive Microwave Imaging System (PMIS) or the Bendix 100 DAS. The tape must be mounted on a nine-track tape drive compatible with the DAS and may be output in either the LARSYS II or Universal format. The display may be made without the color keys (appendixes A and B) or with color keys (see appendix E for tape format). To exercise this option, see FORMAT control card (table 9-1) for the ISOCLS and section 12 (table 12-1) for the DISPLAY processor.[1]

One file is written on the output tape for each field classified or clustered.

5.2 SCATTER PLOT DATA TAPE (PLOTAP, UNIT E)

The SCTRPL processor outputs two-axis color-coded spectral plots on a multifile Universal-formatted tape. The tape default

---

[1]These data are available as input to NDHIST via seven- or nine-track tape or Fastrand.

assignment is unit E, but the user may assign any available unit. (See file assignment chart, table 4-1.) The tape format is defined in appendix F.

5.3 TRANSFORMED DATA TAPE (TRFORM, UNIT L)

The DATA-TR processor outputs a multifile image tape of transformed data. The image tape may be produced in either the LARSYS II or Universal format defined in appendixes A and B, respectively. The tape must be assigned to logical unit L (Fortran unit 14).

File assignments for all processors are given in table 4-1.

6. ONE-DIMENSIONAL HISTOGRAM PROCESSOR – HIST

The processor HIST computes individual field histograms and a total histogram for all the fields and channels defined by the user. An individual statistics report is printed for every field histogrammed. The report contains field descriptions, data ranges, means, standard deviations, and normalized ranges (mean ±3 standard deviations).

A cumulative histogram of all the fields is calculated and written on an internal file to be read later by the GRAYMAP processor. Like the field histograms, a statistics report is printed for the combined fields.

The input DISPLAY control card allows the user to obtain a line printer plot of the histograms. A histogram for each channel on the DISPLAY card (described in table 6-1) is displayed for each field, along with a cumulative histogram for all the fields.

6.1 INPUT FILES

An MSS data tape (DATAPE) must be input. The tape assignment defaults to logical unit C (Fortran unit 3), but, by input of the DATAFILE control card, the user may assign any available logical unit. (See table 4-1 for file assignments and section 3.2, MSS Image Data Tapes, for further information on format.)

6.2 OUTPUT FILES

The HIST processor writes a file for the GRAYMAP processor on logical unit K (Fortran unit 13). This file (HISFIL) contains the histogram data for each channel requested. HISFIL may be assigned to Fastrand or tape or be defaulted (no assignment) to the FH432 drum.

6.3 SCRATCH FILES

The HIST processor does not require an additional scratch file.

6.4 CARD INPUT

The formats for all system card input are defined in section 3.1.

6.4.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$HIST

This card directs the system monitor routine to select the HIST processor and causes all the routines used by the HIST processor to be loaded into the system.

6.4.2 SPECIAL SYSTEM DECKS

The HIST processor does not use any special input decks.

6.4.3 CONTROL CARDS

Control cards allow the user to input various options. These cards are identified by a keyword left justified in columns 1 through 10 of the card, with the parameter values or additional keywords in columns 11 through 72 (beginning in any column after column 10). These control cards may be in any order, but they must be the first cards after the processor card $HIST. Table 6-1 lists all available options, along with their default values.

6.4.4 FIELD DEFINITIONS

Fields to be histogrammed are input immediately following the *END* control card. The card column format for field definitions is defined in section 3.1.2. Input of field definition cards is terminated by the $END* control card.

6.4.5 DECK SETUP

The HIST deck setups are given in figure 6-1. The @ indicates the master punch for the Univac system. Card column 1 is the 7-8 multipunch.

6.5 CARD OUTPUT

This processor does not output any card decks.

6.6 SAMPLE COMPUTER RUNS

The sample test cases shown in figures 6-2 and 6-3 illustrate the output from the HIST processor using all defaults for one run and all options for another, respectively. Two fields from a Hill-County-North data tape were used in each case.

In the first run, four channels were histogrammed using all defaults.

In the second run, three channels were histogrammed but only two were displayed. The minimum radiance XLOW was set to zero while the maximum radiance XHIGH was set to 110. The height of the Y-axis, YSIZ, was set to 12. This run took 1.089 minutes. Appendix G gives execution times for the HIST and other processors.

6.7 RESTRICTIONS

a. The maximum number of channels is 30.

b. The number of histograms requested to be plotted may be limited if internal dimensions are too small for all user requests. (For example, if the user requests 30 channels to be histogrammed, only 14 of those histograms may be plotted; however, all 30 will be histogrammed.)

   This limitation is a function of the number of channels requested on the CHANNELS control card. If too many channels are indicated on the DISPLAY control card, a diagnostic is printed but execution continues.

c. The DISPLAY card must be a subset of the CHANNELS card.

d. The data for all channels for one scan line are unpacked into an array dimensioned 12 000. If the number of channels times [(sample end - sample begin)/sample increment] exceeds 12 000, a diagnostic message is printed. Sample end is reset to fit the dimensions and execution continues.

6.8 DIAGNOSTIC MESSAGES

The diagnostic messages and the subroutines in which they appear are as follows.

6.8.1 SUBROUTINE HISTIC

Message	Explanation
ONLY THE FIRST 50 FIELD DESCRIPTIONS WERE PRINTED, BUT ALL THE FIELDS WERE INCLUDED IN THE TOTAL HISTOGRAMMED STATS.	The user has input more than 50 fields, and only the first 50 field descriptions will be printed in the "Data Blocks Histogrammed" portion of the total report; however, all the input fields were included in the calculations of the "Total Histogrammed Statistics."

6.8.2 SUBROUTINE SETUP5

Message	Explanation
CHANNEL, I2, IS NOT A SUBSET OF THE CHANNELS GIVEN ON CHANNELS CARD.	A channel on the DISPLAY card is not a member of the set of channels on the CHANNELS card.
TOO MANY CHANNELS ARE BEING HISTOGRAMMED AND PLOTTED, NO. OF CHANNELS PLOTTED WAS RESET TO _____.	User requested too many histograms to be plotted. The number of histograms plotted varies according to the number of channels histogrammed.

6.8.3 SUBROUTINE HISTGM

Message	Explanation
TOO MUCH DATA REQUESTED -- SAMPLE END WAS RESET TO _____.	The data for all channels for one scan line are unpacked into an array dimensioned 12 000. If the number of channels times [(sample end - sample begin)/sample increment] exceeds 12 000, this diagnostic is printed. Sample end is reset to fit the dimensions and execution continues.

TABLE 6-1.— HIST PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
CHANNELS	$C_1, C_2, C_3, \cdots, C_k$ $k \leq 30$ Default: None	Channels to be histogrammed, $C_1, C_2, C_3, \cdots, C_k$, should be integer numbers separated by commas.
SIZE	XHIGH=K 0<K<255 Default: XHIGH=255	K is an integer which sets the maximum radiance value which will be histogrammed. XHIGH becomes X_{max} on the X-axis of the histogram plot.[c]
SIZE	XLOW=J 0<J<XHIGH Default: XLOW=0	J is an integer which sets the minimum radiance value which will be histogrammed. XLOW becomes X_{min} on the X-axis of the histogram plot.[c]
SIZE	YSIZ=L $0<L<f(x)_{max}$ Default: YSIZ=15	L is an integer which sets the height of the Y-axis (number of print lines). Using the input YSIZ, the Y-axis scale for the histogram plot will be determined by the processor to be: $f(x)_{max}$+(YSIZ-1)/YSIZ.
DISPLAY	$C_1, C_2, C_3, \cdots, C_k$ $k \leq 30$ Default: No plots	Channels for which histograms will be plotted. $C_1, C_2, C_3, \cdots, C_k$ must be a subset of the CHANNELS card.

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

[c]The difference between XHIGH and XLOW must be at least 100.

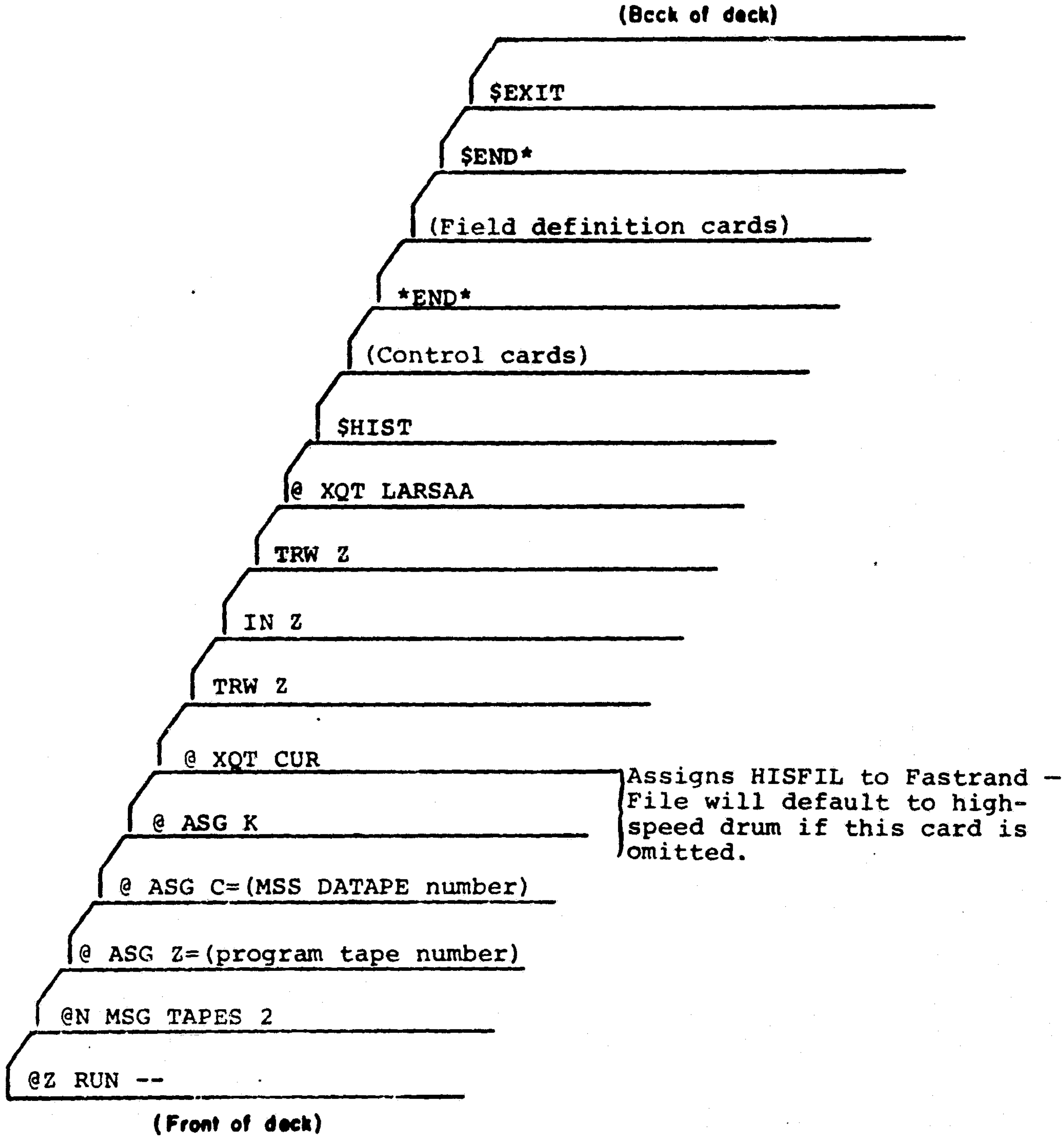
TABLE 6-1.— Continued.

Keyword	Parameter and default values	Function
DATAFILE	UNIT=N,FILE=M Default: N=3,M=1	N is the Fortran logical unit number to which the MSS data tape (DATAPE) has been assigned; M is the file number for the tape to be processed. For back-to-back executions of more than one processor, if using the same file number, only one DATAFILE control card need be submitted.[d]
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.

[d]Appendix H contains a sample run demonstrating use of the DATAFILE control card.

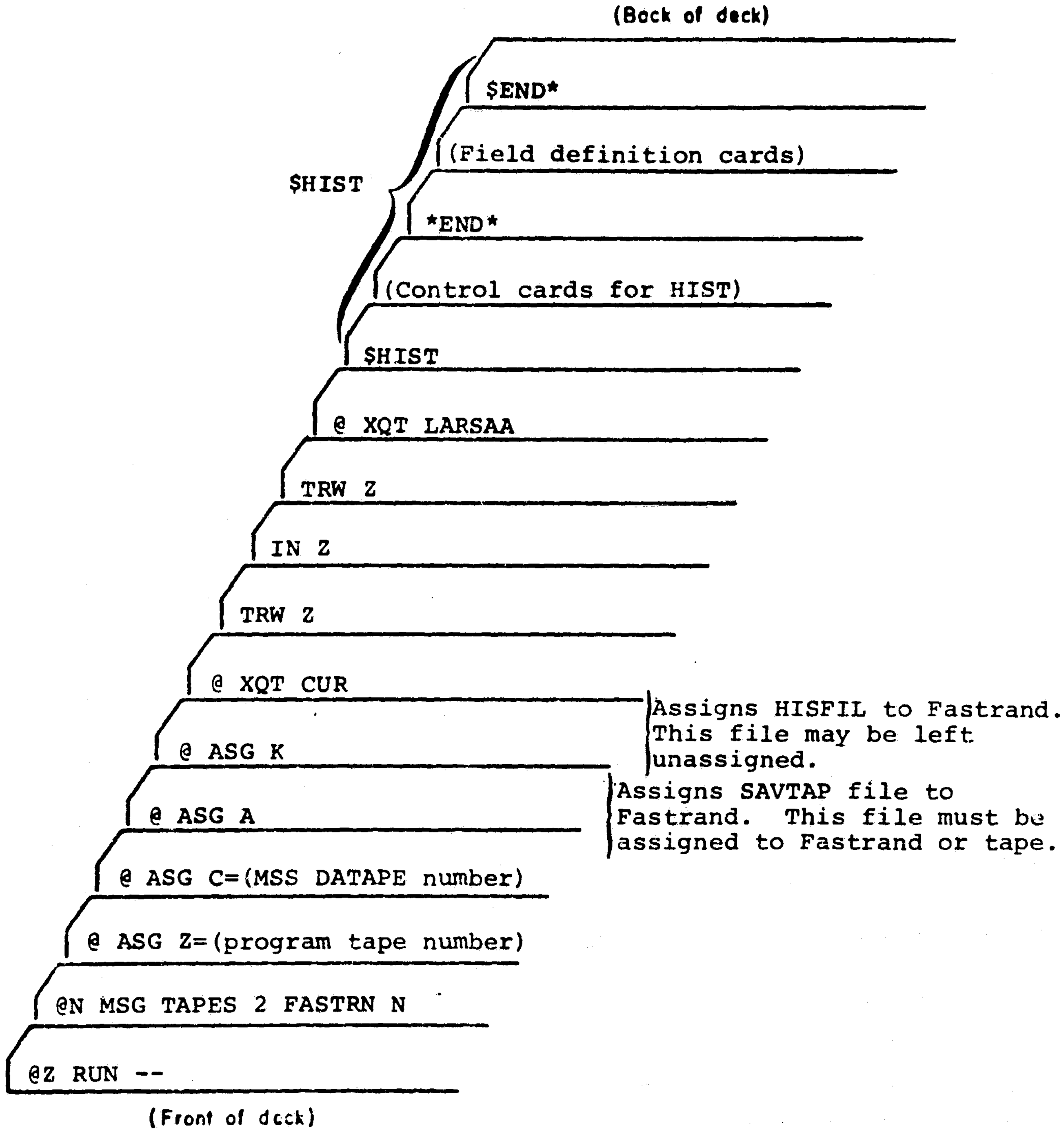
TABLE 6-1.— Concluded.

Keyword	Parameter and default values	Function
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.



(a) For independent execution.

Figure 6-1.– Deck setup for the HIST processor.



(b) For execution with GRAYMAP and STAT.

Figure 6-1.— Continued.

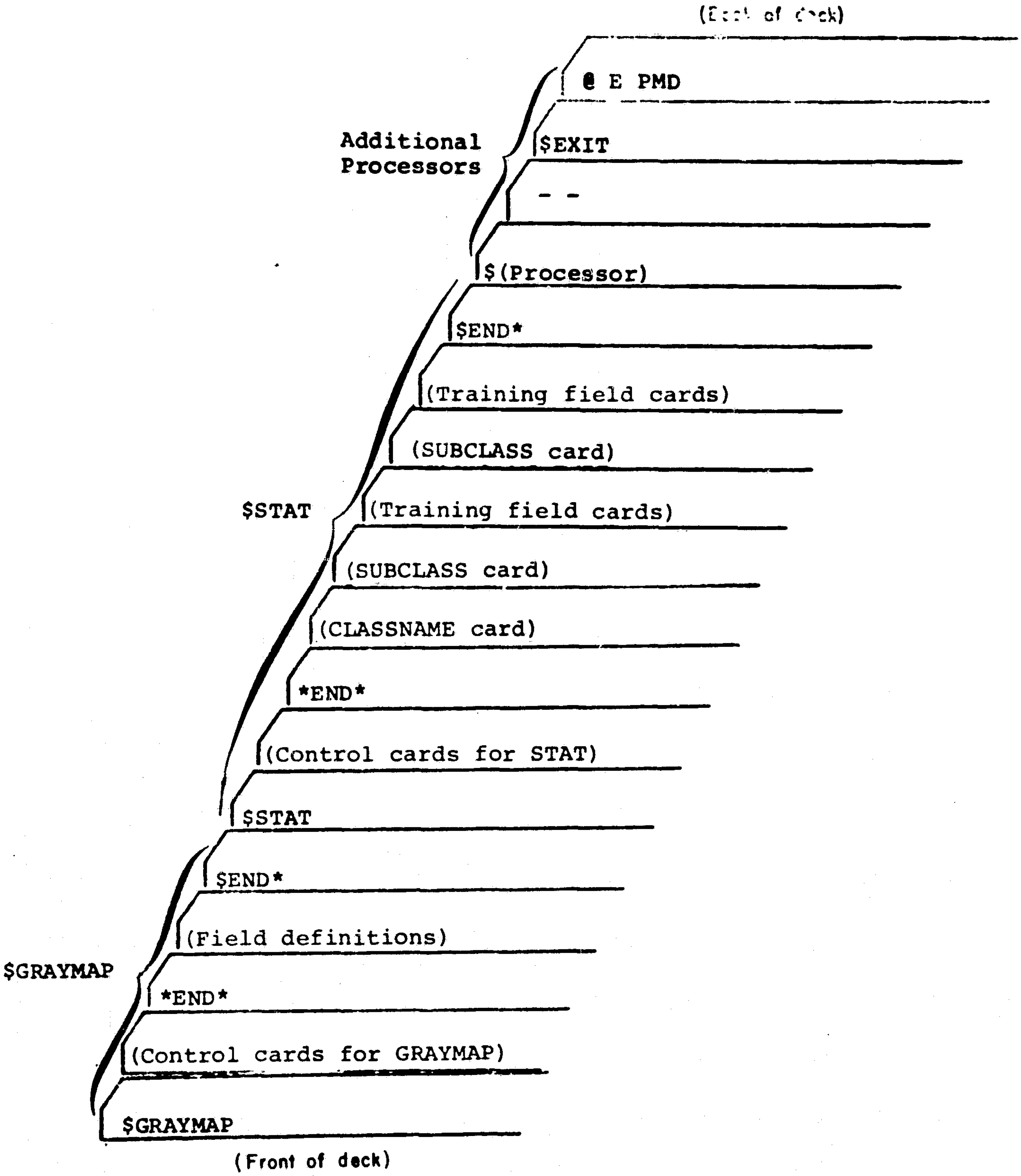


Figure 6-1.— Concluded.

Card	Sample program listing		Comments/commands
1	@Z RUN L78388,TF4,H4,1659,C087,C,20,2	CORBETT 2	EXEC 2 run card
2	@N MSG		EXEC 2 message card
3	@ ASG Z=V03795		Assign EOD-LARSYS program tape
4	@ ASG C=V07536		Assign MSS DATAPE
5	@ XCT CUR		Execute Univac tape complex utility routines
6	TRW Z		Rewind program tape
7	IN Z		Read program tape into system
8	TRW Z		Rewind program tape
9	@ XCT LARSAA		Execute EOD-LARSYS
10	$HIST		Execute HIST processor
11	CHANNELS 1,2,3,4		Histogram these channels
12	*END*		End of control cards
13	H1 (1,1),(20,50),(65,100),(1,19)		Test field definition card 1
14	H3 (1,2),(1,1),(73,199),(340,86) *		Test field definition card 2
15	(18,10)		Continuation of test field definition card 2
16	$END*		End of all input for HIST
17	$EXIT		Exit EOD-LARSYS
18	@E PMD		Give a core dump if the run errs

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Figure 6-2.— Sample program listing and output for the HIST processor using all defaults.

```
$HIST

INPUT SUMMARY
    CHANNE      1,2,3,4
    *END*

INPUT IMAGE DATA TAPE INFORMATION

    FORMAT                    LARSYS 2
    NO. OF CHANNELS              28
    NO. OF PIXELS/LINE          381
    FIRST SCAN LINE NO.           1
    FIRST PIXEL REFERENCE PT      0
```

Figure 6-2.– Continued.

DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)		
1	H1	3	1	1	(1, 19)	(20, 50)	(65, 100)
2	H1	3	1	1	(1, 19)	(20, 50)	(65, 100)
3	H1	3	1	1	(1, 19)	(20, 50)	(65, 100)
4	H1	3	1	1	(1, 19)	(20, 50)	(65, 100)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	24.0	34.0	28.1	2.0	22.0	34.1
2	23.0	37.0	28.0	2.3	21.1	34.9
3	22.0	35.0	27.3	2.3	20.6	34.1
4	10.0	18.0	13.2	1.2	9.6	16.9

Figure 6-2.— Continued.

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

11 SEP 75

DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)			
1	H3	4	1	2	(1, 1)	(73, 199)	(340, 86)	(18, 10)
2	H3	4	1	2	(1, 1)	(73, 199)	(340, 86)	(18, 10)
3	H3	4	1	2	(1, 1)	(73, 199)	(340, 86)	(18, 10)
4	H3	4	1	2	(1, 1)	(73, 199)	(340, 86)	(18, 10)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	16.0	77.0	28.7	6.7	8.5	48.9
2	15.0	76.0	28.3	5.9	10.7	46.0
3	7.0	127.0	27.1	4.9	12.5	41.7
4	2.0	21.0	12.8	1.8	7.3	18.2

Figure 6-2.— Continued.

11 SEP 75

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

DATA BLOCK(S) HISTOGRAMMED

FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)
H1	3	1	1	(1, 19) (20, 50) (65, 100)
H3	4	1	2	(1, 11) (73, 199) (340, 86) (18, 10)

TOTAL
HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	16.0	77.0	28.7	6.7	8.7	48.7
2	15.0	76.0	28.3	5.8	10.8	45.8
3	7.0	127.0	27.1	4.8	12.6	41.6
4	2.0	21.0	12.8	1.8	7.3	18.2

TIME FOR HISTOGRAM 1.232

Figure 6-2.— Concluded.

Card	Sample program listing		Comment/command
1	@Z RUN L78388,TF4,H4,1659,C087,C,20,10	CORBETT 2	EXEC 2 run card
2	@N MSG		EXEC 2 message card
3	@ ASG Z=V03795		Assign EOD-LARSYS program tape
4	@ ASG C=V07536		Assign MSS DATAPE
5	@ ASG K		Assign HISFIL to Fastrand
6	@ XQT CUR		Execute Univac tape complex utility routines
7	TRW Z		Rewind program tape
8	IN Z		Read program tape into system
9	TRW Z		Rewind program tape
10	@ XQT LARSAA		Execute EOD-LARSYS
11	$HIST		Execute HIST processor
12	DATE 8/27/75		Date used in heading printout
13	CHANNELS 1,2,5		Channels histogrammed
14	DISPLAY 2,5		Channels displayed
15	SIZE YSIZ=12,XHIGH=110,XLOW=0		Set the scaling factors in histograms
16	COMMEN HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA		
17	HED1 **PHASE II**		Set the heading for printout
18	HED2 *LARSAA*		
19	*END*		End control card input
20	H1 (1,1),(20,50),(65,100),(1,19)		Test field definition 1
21	H2 (2,3),(1,10),(210,175),(150,200),(75,50)	*	Test field definition 2
22	(18,10)		Continuation of test field definition 2
23	$END*		End of all input for HIST
24	$EXIT		Exit EOD-LARSYS
25	@E PMD		Give a core dump if the run errs

Figure 6-3.— Sample program listing and output for the HIST processor using all options.

```
$HIST

INPUT SUMMARY
     DATE       8/27/75
     CHANNE     1,2,5
     DISPLA     2,5
     SIZE       YSIZ=12,XHIGH=115,XLOW=C
     COMMEN     HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA
     HED1               ..PHASE II..
     HED2               .LARSAA.
     .END.

INPUT IMAGE DATA TAPE INFORMATION

     FORMAT                     LARSYS 2
     NO. OF CHANNELS              28
     NO. OF PIXELS/LINE          381
     FIRST SCAN LINE NO.           1
     FIRST PIXEL REFERENCE PT      0
```


Figure 6-3.– Continued.

PHASE II
LARSAA

8/27/75

HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA

DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)		
1	HI	3	1	1	(1, 19)	(20, 50)	(65, 100)
2	HI	3	1	1	(1, 19)	(20, 50)	(65, 100)
5	HI	3	1	1	(1, 19)	(20, 50)	(65, 100)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	24.0	39.0	28.1	2.0	22.0	34.1
2	23.0	37.0	28.0	2.3	21.1	34.9
5	41.0	54.0	46.9	2.4	39.5	54.2

Figure 6-3.— Continued.

PHASE II
LARSAA

8/27/75

HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA

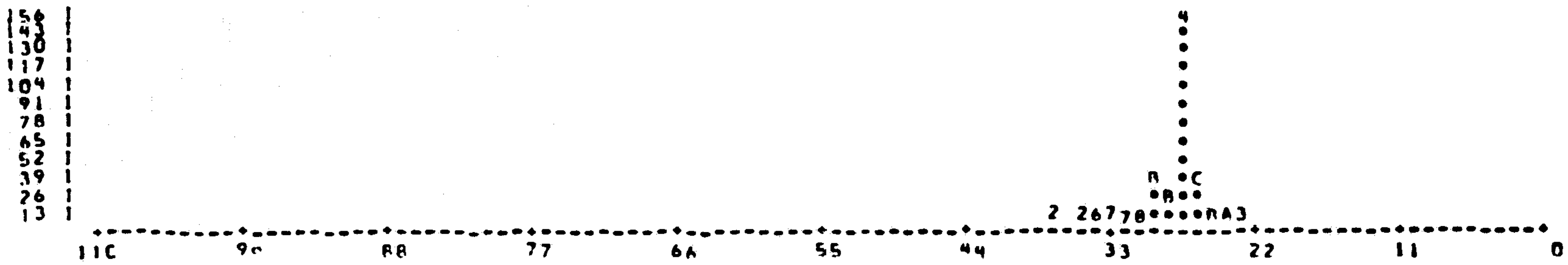
HISTOGRAM

FIELD H1

(NO. SAMPLES : 3021)

CHANNEL 2

EACH * REPRESENTS 13 POINT(S).



CHANNEL 5

EACH * REPRESENTS 7 POINT(S).

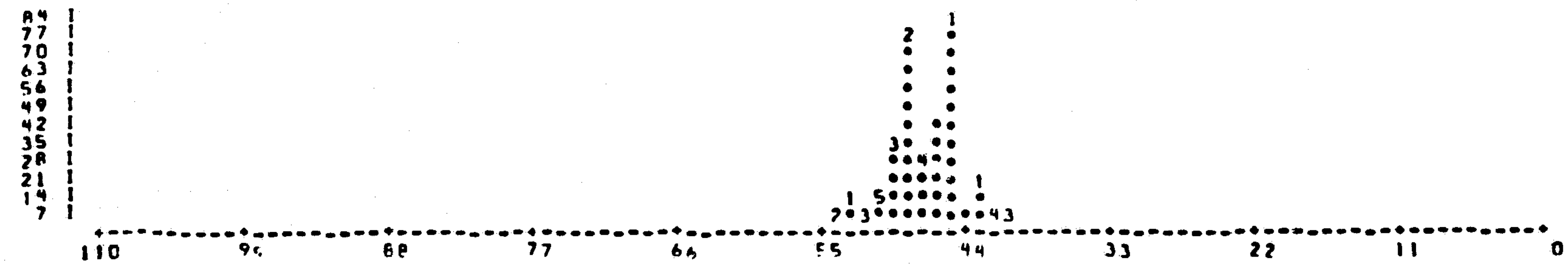


Figure 6-3.– Continued.

PHASE II
LARSAA

8/27/75

HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA

DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)				
1	H2	5	2	3	(1, 10)	(210, 175)	(150, 200)	(75, 50)	(18, 10)
2	H2	5	2	3	(1, 10)	(210, 175)	(150, 200)	(75, 50)	(18, 10)
5	H2	5	2	3	(1, 10)	(210, 175)	(150, 200)	(75, 50)	(18, 10)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	17.0	44.0	27.1	3.1	17.9	36.3
2	15.0	49.0	26.1	4.3	13.0	39.1
5	27.0	59.0	41.6	5.4	25.5	57.7

Figure 6-3.— Continued.

PHASE II 8/27/75
LARSAA

HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA

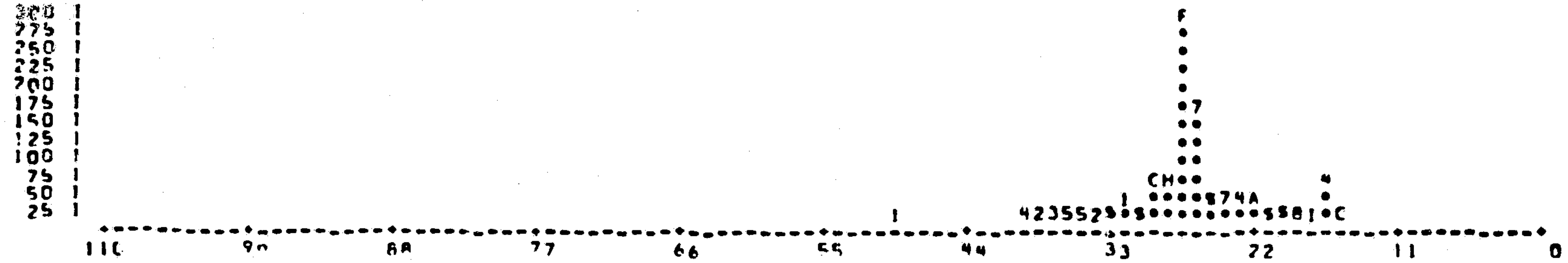
HISTOGRAM

FIELD H2

(NO. SAMPLES : 9471)

CHANNEL 2

EACH • REPRESENTS 25 POINT(S).



CHANNEL 5

EACH • REPRESENTS 19 POINT(S).

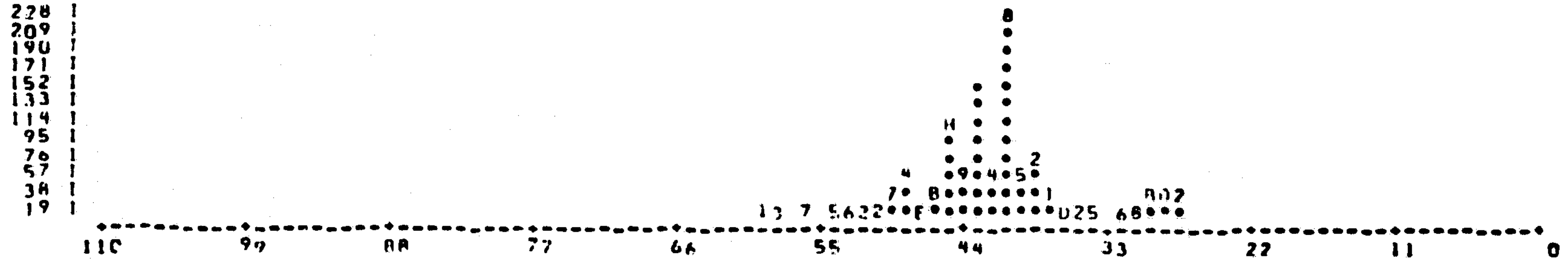


Figure 6-3.– Continued.

PHASE II
LARSAA

8/27/75

HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA

DATA BLOCK(S) HISTOGRAMMED

FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)
H1	3	1	1	(1, 19) (20, 50) (65, 100)
H2	5	2	3	(1, 10) (210, 175) (150, 200) (75, 50) (10, 10)

TOTAL
HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	17.0	44.0	27.3	2.9	18.7	35.9
2	15.0	49.0	26.5	4.0	14.4	38.6
5	27.0	59.0	42.9	5.3	26.9	58.8

Figure 6-3.– Continued.

PHASE II
LARSAA

8/27/75

HISTOGRAM OF HILL COUNTY DATA,PHASE II LARSAA

HISTOGRAM

TOTAL

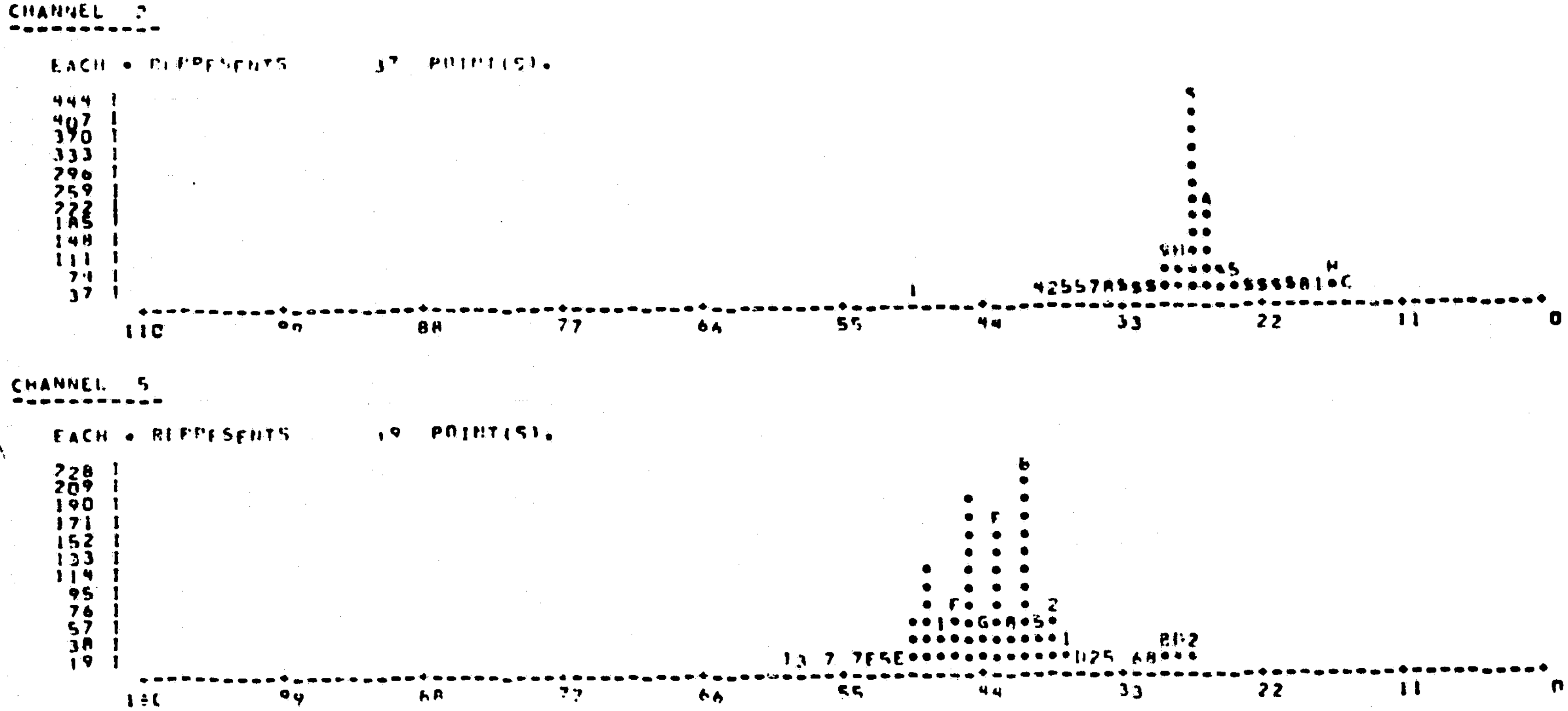


Figure 6-3.— Concluded.

7. GRAYMAP PROCESSOR

The chief purpose of GRAYMAP is to produce alphanumeric pictorial printouts of digitized airborne MSS data. Each data sample is eight bits, providing 256 possible gray levels for each MSS data channel. To allow a meaningful distinction in gray-scale tones, GRAYMAP assigns each of the 256 levels to 1 of as many as 16 possible symbols. These symbols may be preassigned or arbitrarily assigned for each run. The specifications for the bin edges for each symbol may be assigned arbitrarily by the user for each run or computed from the histogram data in order to result in equal activity for each of the symbols. In any case, the data are subsequently output in terms of symbols, and each symbol represents a range of data values in which the corresponding data points fall.

7.1 INPUT FILES

An MSS data tape (DATAPE) must be input to the GRAYMAP processor. The tape assignment defaults to logical unit C (Fortran unit 3); however, by input of the DATAFILE control card, the user may assign any available logical unit. (See table 4-1 for file assignments and section 3.2, MSS Image Data Tapes, for further information on format.)

The GRAYMAP processor requires the bin levels to be input on a control card or computed from the histograms output by the HIST processor on the HISFIL file. When the bin levels are to be computed, logical unit K (Fortran unit 13) may be assigned to either Fastrand or tape or allowed to default to drum (no assignment). If the HIST processor has not been executed prior to running GRAYMAP and bin levels have not been input, a default histogram of every 10th line for 500 lines and every 10th sample for 200 samples is computed, and HISFIL is created on logical unit K.

Figure 7-1 shows the interaction of the HIST and GRAYMAP processors.

7.2 OUTPUT FILES

No files are output by the GRAYMAP processor.

7.3 SCRATCH FILES

The GRAYMAP processor does not require additional scratch files.

7.4 CARD INPUT

All system card input formats referred to in this section are defined in section 3.1.

7.4.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$GRAYMAP

This card directs the system monitor routine to select the GRAYMAP processor and initiates loading of routines used by GRAYMAP.

7.4.2 SPECIAL SYSTEM DECKS

None of the special system card decks are required for this processor.

7.4.3 CONTROL CARDS

Table 7-1 lists all available options and control cards recognized by GRAYMAP, along with their default values.

7.4.4 FIELD DEFINITIONS

Fields for which gray-scale maps are desired must follow the *END* control card. See section 3.1.3 for the format of field

definition cards. Field definition input is terminated by the $END* control card.

7.4.5 DECK SETUP

The GRAYMAP deck setups are given in figure 7-2. The @ indicates the master punch for the Univac system, which is the 7-8 multi-punch. The deck setup in figure 7-2(a) allows HISFIL on unit K to default to drum.

7.5 CARD OUTPUT

The GRAYMAP processor produces no card output.

7.6 SAMPLE COMPUTER RUNS

Test case 1 for GRAYMAP (fig. 7-3) illustrates the output when the bin levels and two sets of symbols are input. Two channels from a Hill-County-North data tape were input, but only the output from channel 1 is shown.

Test case 2 for HIST and GRAYMAP (fig. 7-4) included channels 1 and 2. The bin levels were calculated from the histogrammed data and default symbols were used. HIST took 0.748 minute while GRAYMAP took 2.215 minutes. All the output from HIST is shown, but only channel 1 output from GRAYMAP is included. Appendix G gives sample execution times for the HIST, GRAYMAP, and other processors.

7.7 RESTRICTIONS

The system-related restrictions in section 17 apply to this processor.

The maximum number of channels allowed is 30, and the maximum number of bin levels is 16.

7.8 DIAGNOSTIC MESSAGES

Message	Explanation
BAD SUPERVISOR CONTROL CARD.	Check spelling of keyword.
ONLY 16 BINLEVELS PERMITTED.	Reduce the number of bin levels to 16.
THIS CHANNEL IS NOT HISTOGRAMMED.	Check CHANNELS control card and make sure all channels requested have been histogrammed.
THIS CHANNEL IS OUT OF NUMERICAL RANGE AND WAS IGNORED.	All channels requested must be in the range 1 to 30.
YOU HAVE ASKED FOR TOO MANY SAMPLES. THE LAST SAMPLE IS __________.	The last sample is reset to the last sample on the data tape.

TABLE 7-1.– GRAYMAP PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
CHANNELS	$C_1,C_2,C_3,\cdots,C_k$ $k\leq30$ Default: Gray map for all channels on HISFIL (created by a previous execution of HIST)	Provides pictorial printout for requested channels.
BINLEVEL	$N_1,N_2,N_3,\cdots,N_k$ $k\leq16$ Default: Histograms used to set bin levels	Upper bin edges for gray-scale levels with a range of 0 to 255 and a maximum of 16 levels; the last bin level should always be 255.
SYMBOLS	$S_1,S_2,S_3,\cdots,S_k$ $k\leq16$ Default: Two sets of 10 symbols overprinted, resulting in one of $,X,θ,0,*,=,·,-,/,b	Character set separated by commas, with a maximum of 16 symbols per SYMBOL card. If 2 sets are input, the second overprints the first. The number of symbols input on one card determines the number of bin levels when using the histograms to set the levels. Blank is a legitimate character.
DATAFILE	UNIT=N,FILE=M Default: N=3,M=1	N is the Fortran logical unit number to which the image data tape has been assigned; M is the file number on the tape to

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 7-1.— Concluded.

Keyword	Parameter and default values	Function
		be processed. For back-to-back executions of more than one processor, if using the same file number, only one DATAFILE control card need be submitted.
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

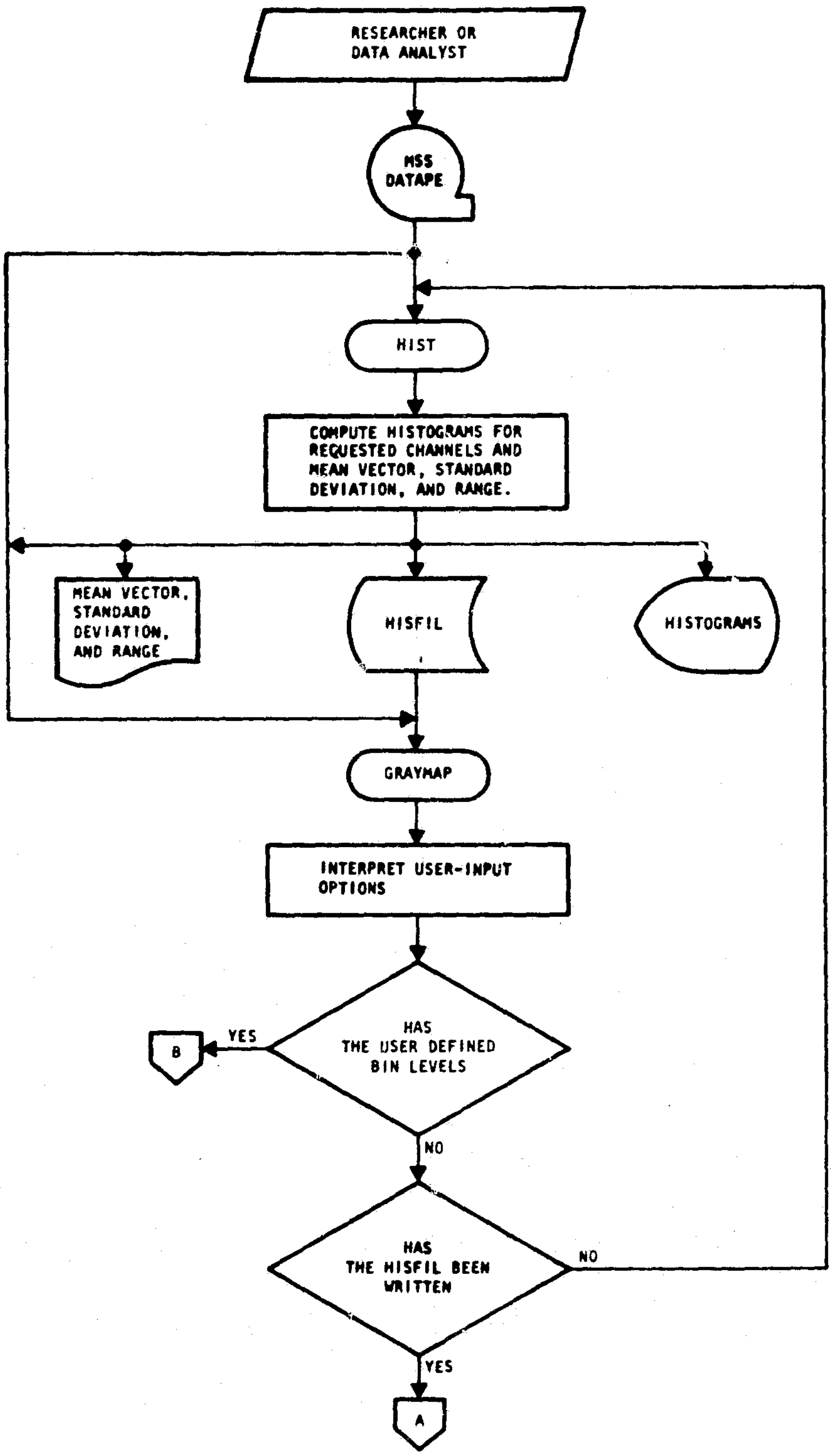


Figure 7-1.— Functional diagram showing interaction of the HIST and GRAYMAP processors.

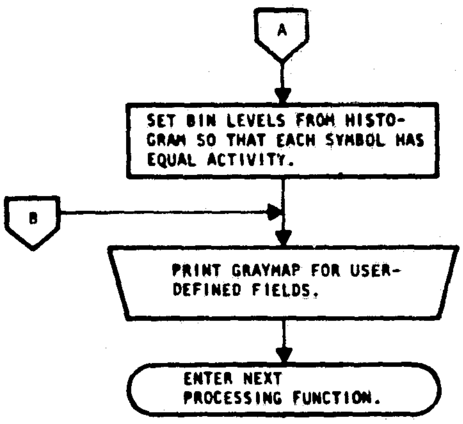
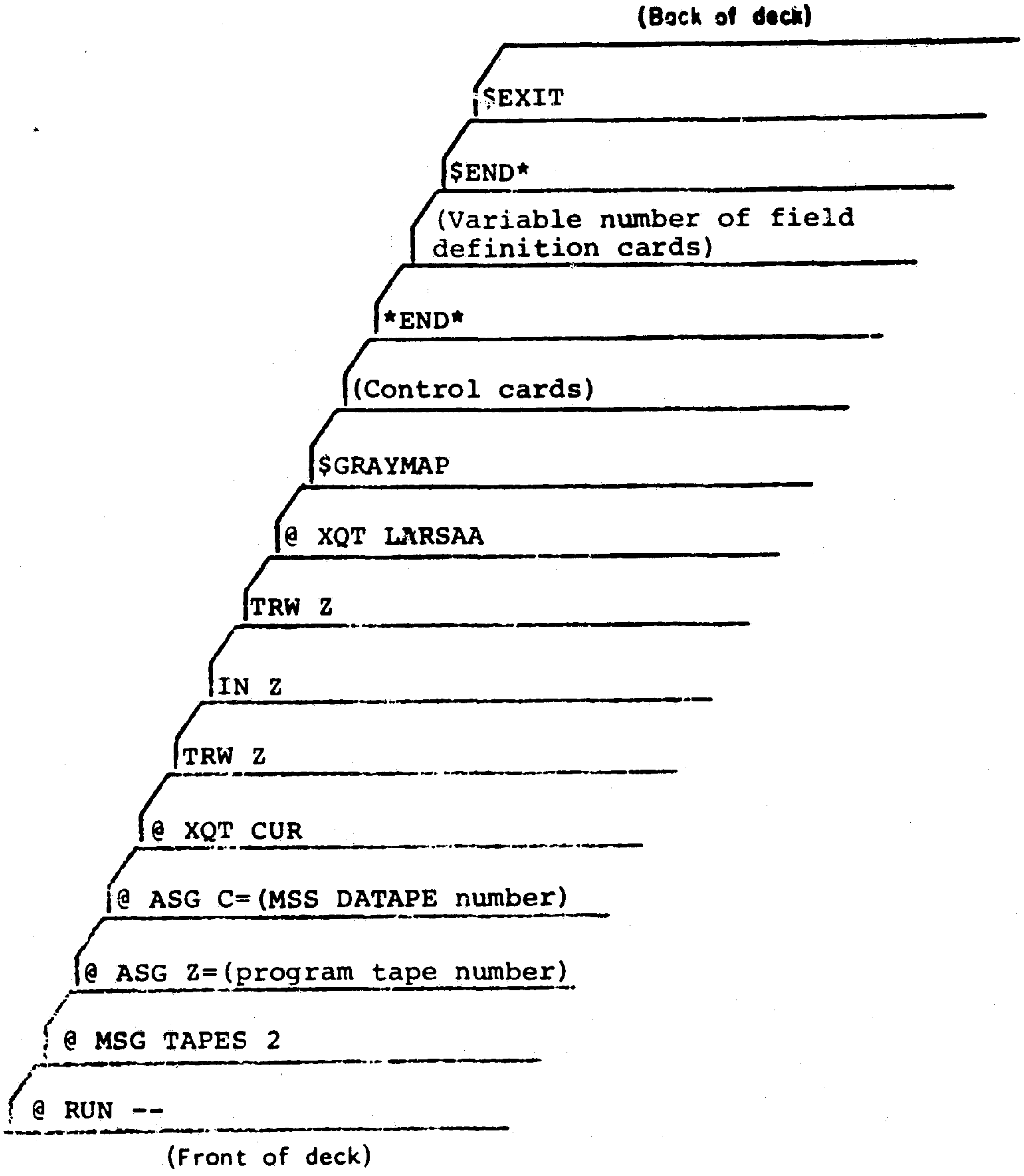
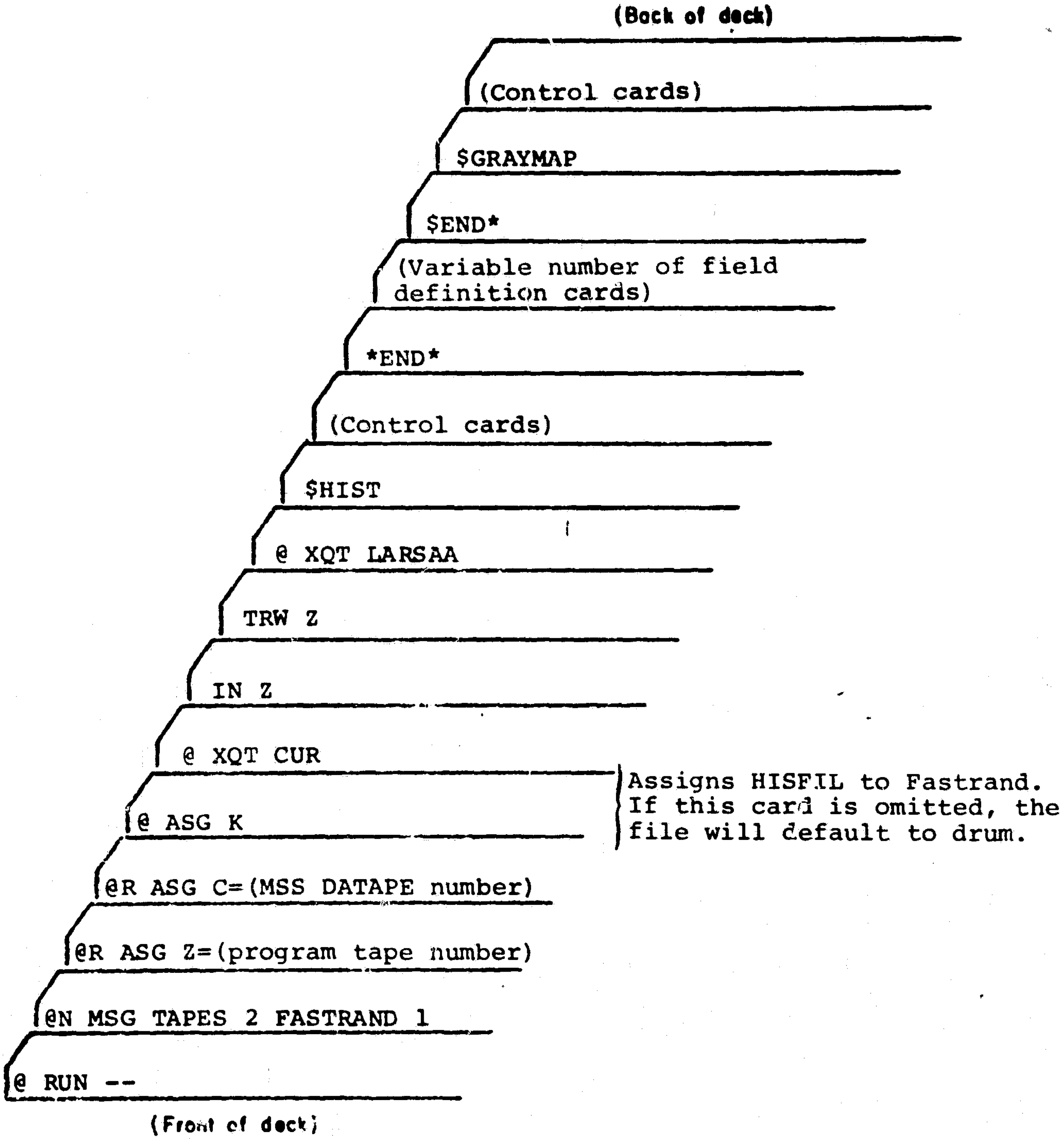


Figure 7-1.– Concluded.



(a) For independent execution.

Figure 7-2.– Deck setup for the GRAYMAP processor.



(b) For execution back to back with HIST.

Figure 7-2.– Continued.

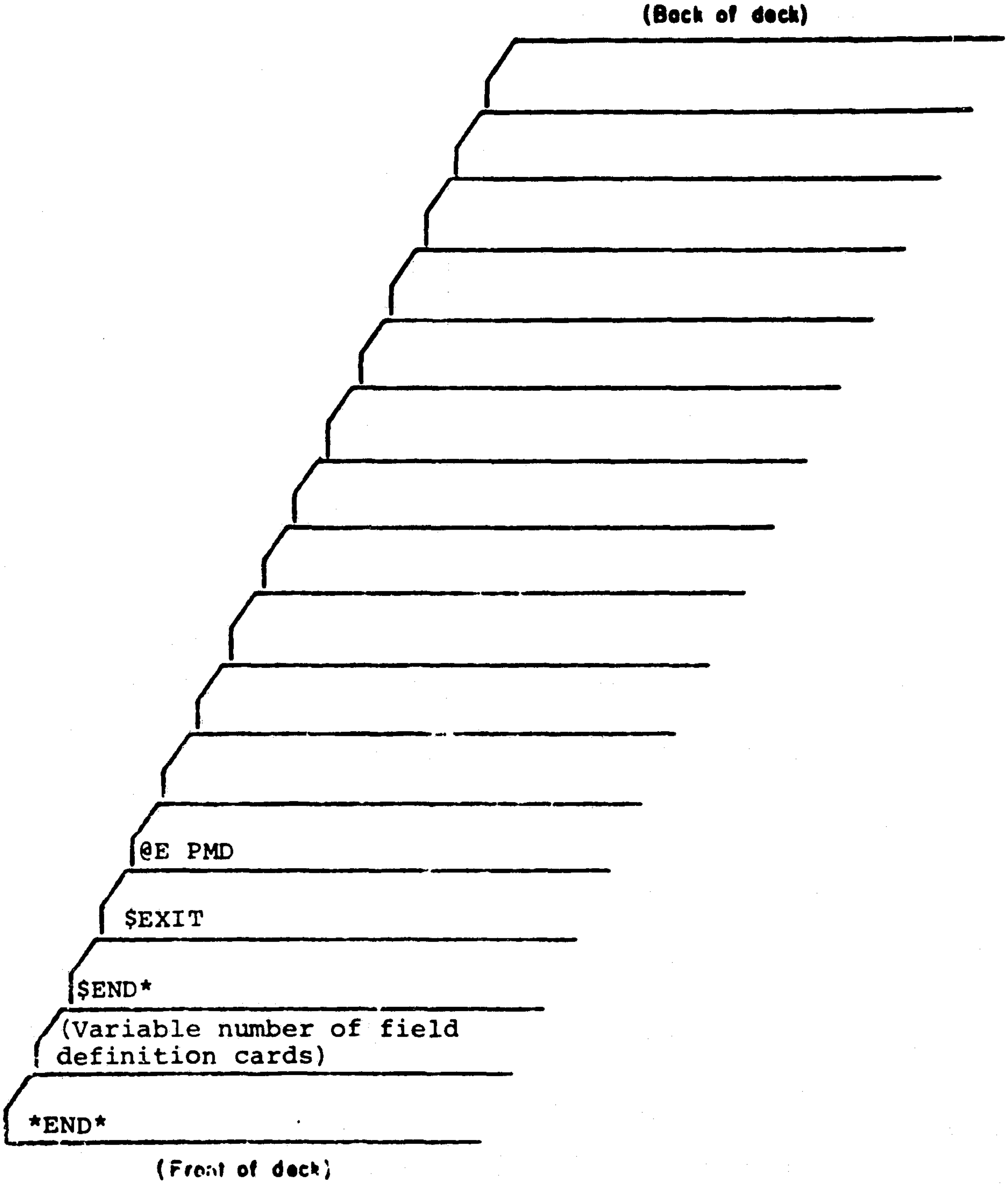


Figure 7-2.– Concluded.

Card	Sample program listing	Comment/command
1	@Z RUN L78388,TF4,AG2,1659,C087,C,10,5	CORBETT BW EXEC 2 run card
2	@N MSG 2 TAPES	EXEC 2 message card
3	@ ASG C=V07536	Assign MSS DATAPE
4	@ ASG Z=V03795	Assign EOD-LARSYS program tape
5	@ XQT CUR	Execute Univac tape complex utility routines
6	TRW Z	Rewind program tape
7	IN Z	Read program tape into system
8	TRW Z	Rewind program tape
9	@ XQT LARSAA	Execute EOD-LARSYS
10	$GRAYMAP	Execute GRAYMAP processor
11	CHANNELS 1,2	Channels to be graymapped
12	BINLEV 5,10,15,18,20,23,30,255	Set bin levels
13	SYMBOL M,X,O,0,*,=,;,.,-	Assign symbols
14	SYMBOL $,=,-,0,-,=,.,.,-	
15	DATE 8/27/75	
16	COMMEN PHASE II GRAYMAP - HILL COUNTY DATA	
17	HED1 ***PHASE II LARSYS PROGRAM ***	Set the heading for printout
18	HED2 **SAMPLE OUTPUT **	
19	*END*	End of control card input
20	TSTFLD (2,1),(1,1),(50,10),(340,140),(200,75)*	Test field definition 1
21	(23,115)	Continuation of test field definition 1
22	$END*	End of all input for GRAYMAP
23	$EXIT	Exit EOD-LARSYS
24	@E PML	Give a core dump if the run errs

Figure 7-3.— Program listing and output for the GRAYMAP processor with bin levels and two sets of symbols input.

```
$GRAYMAP

    CHANNE      1,2
    BINLEV      5,10,15,18,20,23,30,255
    SYMBOL      M,X,O,O,*,=,.,-
    SYMBOL      $,=,-,O,-,*,.,-
    DATE        8/27/75
    COMMEN      PHASE II GRAYMAP - HILL COUNTY DATA
    HED1                   ...PHASE II LARSYS PROGRAM ...
    HED2                    ..SAMPLE OUTPUT ..
    *END*
SUPERVISOR INFORMATION FOR GRAYMAP
CHANNELS GRAYMAPPED ARE    1    2
SYMBOLS USED IN GRAYMAP ARE   ■   ■   ■   O   •   •   •   -


INPUT IMAGE DATA TAPE INFORMATION

    FORMAT                      LARSYS 2
    NO. OF CHANNELS                28
    NO. OF PIXELS/LINE            381
    FIRST SCAN LINE NO.             1
    FIRST PIXEL REFERENCE PT        0
```

Figure 7-3.– Continued.

```
                         ***PHASE II LARSYS PROGRAM ***                                          8/27/75
                          **SAMPLE OUTPUT **
     PHASE II GRAYMAP - HILL COUNTY DATA

                             SAMPLE   LINE     NO. OF
CHANNEL    FIELDNAME          INC      INC    VERTICES    VERTICES(SAMPLE,LINE)
   1        TSTFLD             2        1         5       (   1,   1) (  50,  10) ( 340, 140) ( 200,  75) (  23, 115)
```

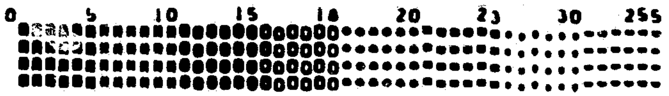


Figure 7-3.— Continued.

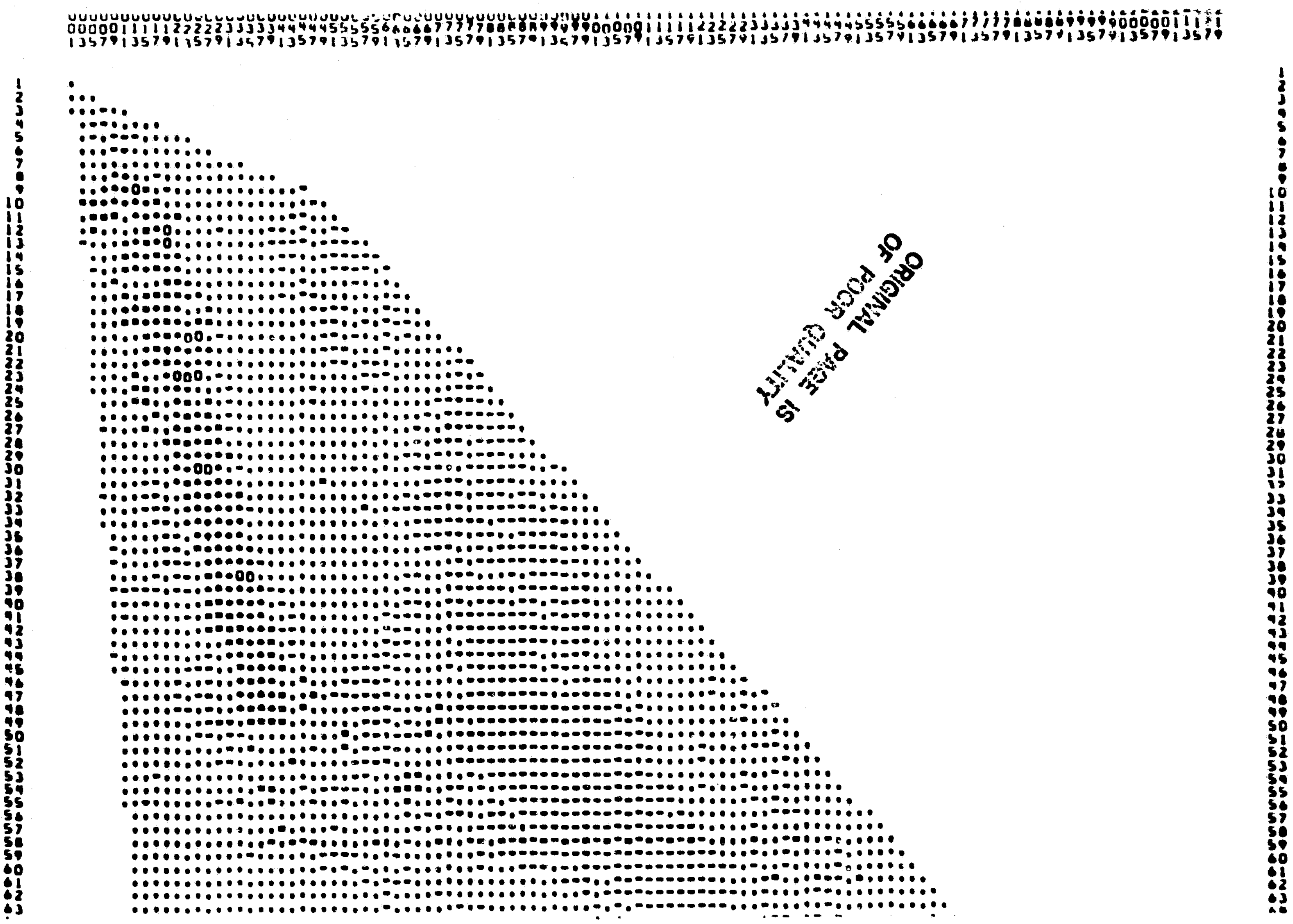


Figure 7-3.- Continued.

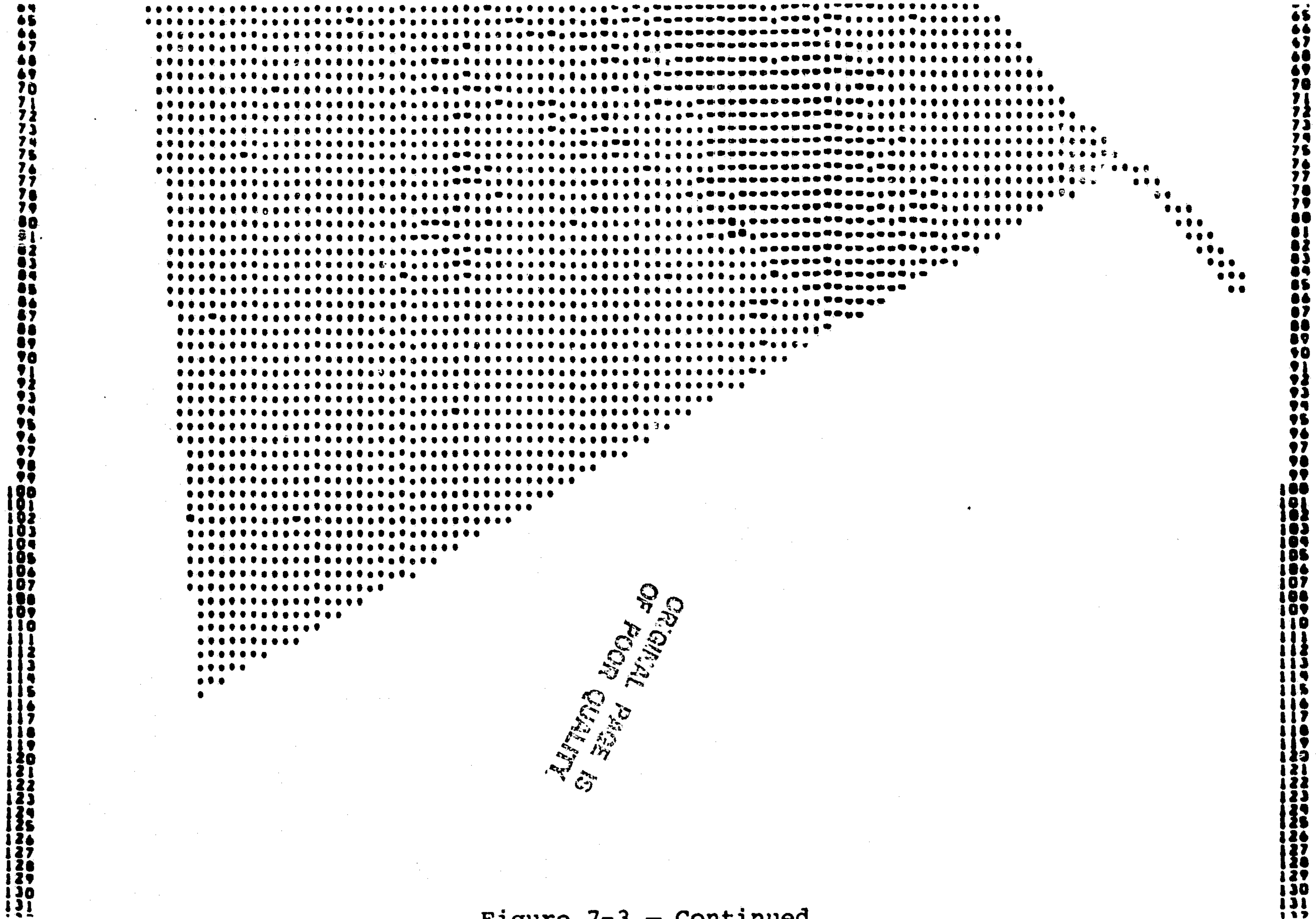


Figure 7-3.– Continued.

C-2

```
132                                                                                                                    132
133                                                                                                                    133
134                                                                                                                    134
135                                                                                                                    135
136                                                                                                                    136
137                                                                                                                    137
138                                                                                                                    138
139                                                                                                                    139
140                                                                                                                    140

      00000000000000000000000000000000000000000000000000111111111111111111111111111111111111111111111111112222222222
      00000111112222233333444445555566666777778888899999000001111122222333334444455555666667777788888999990000011111
      13579135791357913579135791357913579135791357913579135791357913579135791357913579135791357913579135791357913579
```

Figure 7-3.– Continued.

```
222222222222222222222222222222222222222233333333333333333333
222223333344444555556666677777888889999900000111112222233333
135791357913579135791357913579135791357913579135791357913579
```

Figure 7-3.– Continued.

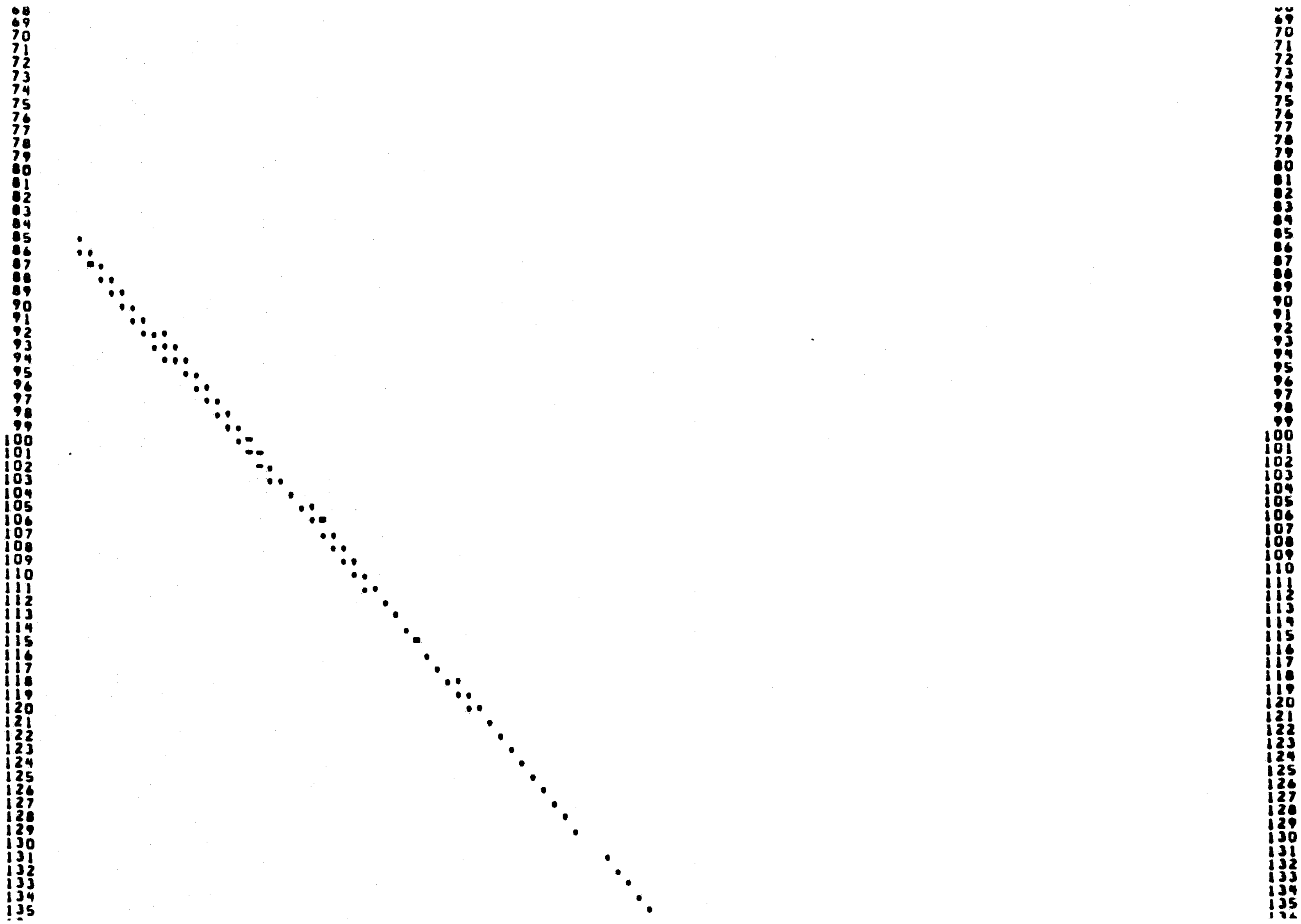


Figure 7-3.– Continued.

136
137
138
139
140

```
222222222222222222222222222222222222222233333333333333333333
222223333344444555556666677777888889999900000111112222233333
135791357913579135791357913579135791357913579135791357913579
```

136
137
138
139
140

Figure 7-3.– Concluded.

Card	Sample program listing	Comment/command
1	@Z RUN L78388,TF4,H4,1659=C 87,C=20,2 CORBE33 3	EXEC 2 run card
2	@N MSG	EXEC 2 message card
3	@ ASG C=V07536	Assign MSS DATAPE
4	@ ASG Z=V03795	Assign EOD-LARSYS program tape
5	@ XQT CUR	Execute Univac tape complex utility routines
6	TRW Z	Rewind program tape
7	IN Z	Read program tape into system
8	TRW Z	Rewind program tape
9	@ XCT LARSAA	Execute EOD-LARSYS
10	$HIST	Execute HIST processor
11	CHANNELS 1,2	Channels to be histogrammed
12	*END*	End of control card input
13	HIST1 (1,1),(1,1),(340,110),(200,213), (156,195)*	Test field definition card 1
14	(20,16)	Continuation of test field definition card 1
15	$END*	End of all input for HIST
16	$GRAYMP	Execute GRAYMAP processor
17	COMMEN GRAYMAP OF HILL COUNTY DATA USING BINLEVELS COMPUTED BY HIST	Comment used in heading printout
18	*END*	End of control card input
19	GRAY1 (1,1),(20,19),(150,3),(110,95),(1,50)	Training field definition card 1
20	$END*	End of all input for GRAYMAP
21	$EXIT	Exit EOD-LARSYS
22	@F PMD	Give a core dump if run errors

Figure 7-4.– Program listing and output for the GRAYMAP processor using histogrammed data and default symbols.

LYNDON B. JOHNSON SPACE CENTER 10 SEP 75
HOUSTON, TEXAS

```
$HIST

INPUT SUMMARY
    CHANNE     1,2
    *END*

INPUT IMAGE DATA TAPE INFORMATION

    FORMAT                      LARSYS 2
    NO. OF CHANNELS                   28
    NO. OF PIXELS/LINE               381
    FIRST SCAN LINE NO.                1
    FIRST PIXEL REFERENCE PT           0
```

Figure 7-4.— Continued.

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HOUSTON, TEXAS

10 SEP 75

DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)				
1	HIST1	5	1	1	(1, 1)	(349, 110)	(200, 213)	(156, 195)	(20, 16)
2	HIST1	5	1	1	(1, 1)	(349, 110)	(200, 213)	(156, 195)	(20, 16)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	16.0	77.0	29.1	7.1	7.9	50.4
2	14.0	76.0	29.4	6.4	9.0	47.7

Figure 7-4.— Continued.

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10 SEP 78

DATA BLOCK(S) HISTOGRAMMED

FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)
HIST1	5	1	1	(1, 1) (399, 110) (200, 213) (156, 195) (20, 16)

TOTAL
HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	16.0	77.0	29.1	7.1	7.9	50.4
2	14.0	76.0	28.4	6.4	9.0	47.7

TIME FOR HISTOGRAM .748

Figure 7-4.- Continued.

```
                                   LYNDON B. JOHNSON SPACE CENTER           10 SEP 75
                                          HOUSTON,TEXAS

$GRAYMP

   COMMEN    GRAYMAP OF HILL COUNTY DATA USING BINLEVELS COMPUTED BY HIST
   *END*
SUPERVISOR INFORMATION FOR GRAYMAP
CHANNELS GRAYMAPPED ARE   1   2
SYMBOLS USED IN GRAYMAP ARE  ■  &  0  O  *  *  .  .  /


INPUT IMAGE DATA TAPE INFORMATION

    FORMAT                    LARSYS 2
    NO. OF CHANNELS              28
    NO. OF PIXELS/LINE          381
    FIRST SCAN LINE NO.           1
    FIRST PIXEL REFERENCE PT      0
```

~~7-25~~
88

Figure 7-4.— Continued.

LYNDON B. JOHNSON SPACE CENTER 10 SEP 76
HOUSTON, TEXAS

GRAYMAP OF HILL COUNTY DATA USING BINLEVELS COMPUTED BY HIST

CHANNEL	FIELDNAME	SAMPLE INC	LINE INC	NO. OF VERTICES	VERTICES(SAMPLE,LINE)
1	GRAY1	1	1	4	(1, 50) (20, 19) (150, 3) (110, 95)

0 24 25 26 27 28 29 30 31 33 255

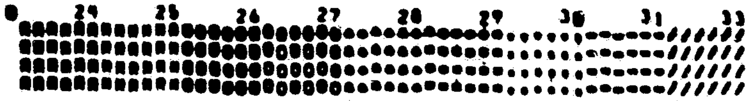


Figure 7-4.– Continued.

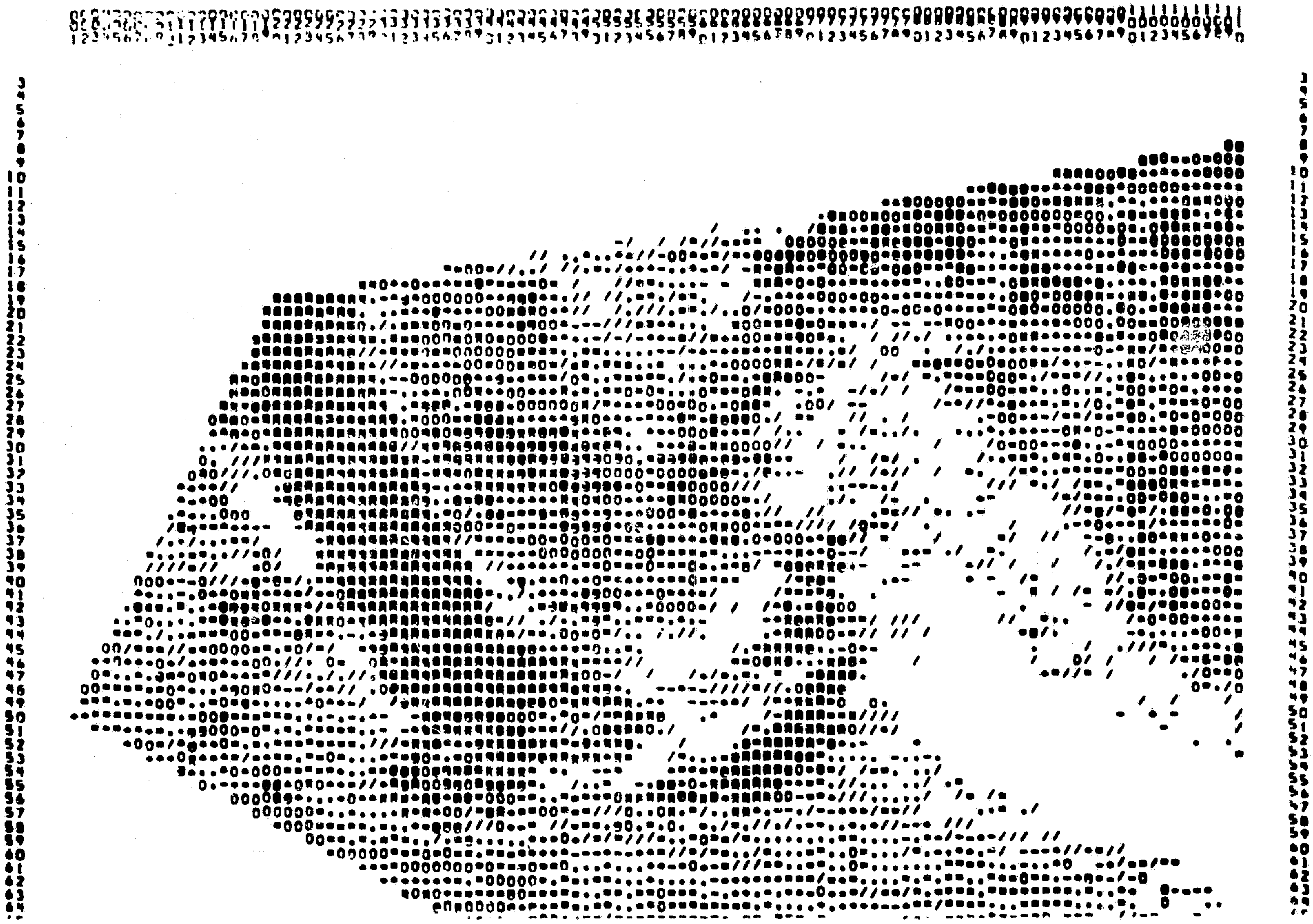


Figure 7-4.— Continued.

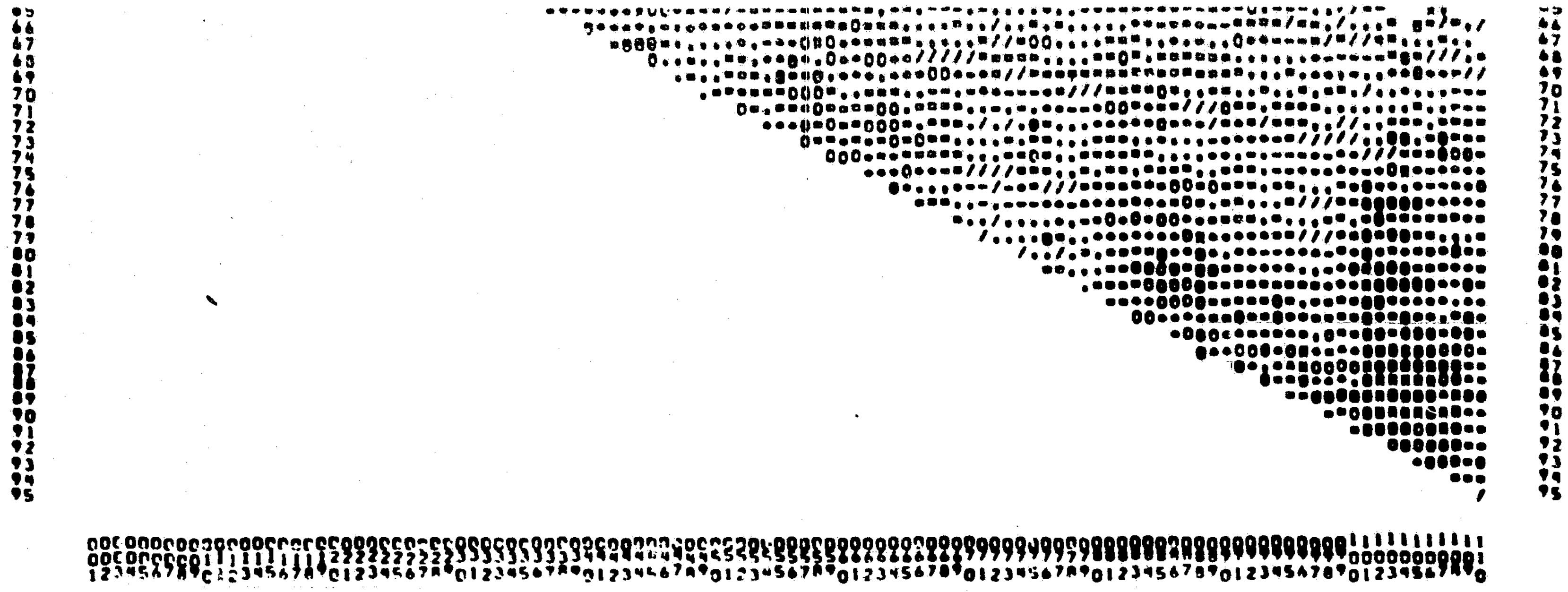


Figure 7-4.— Continued.

Figure 7-4.– Continued.

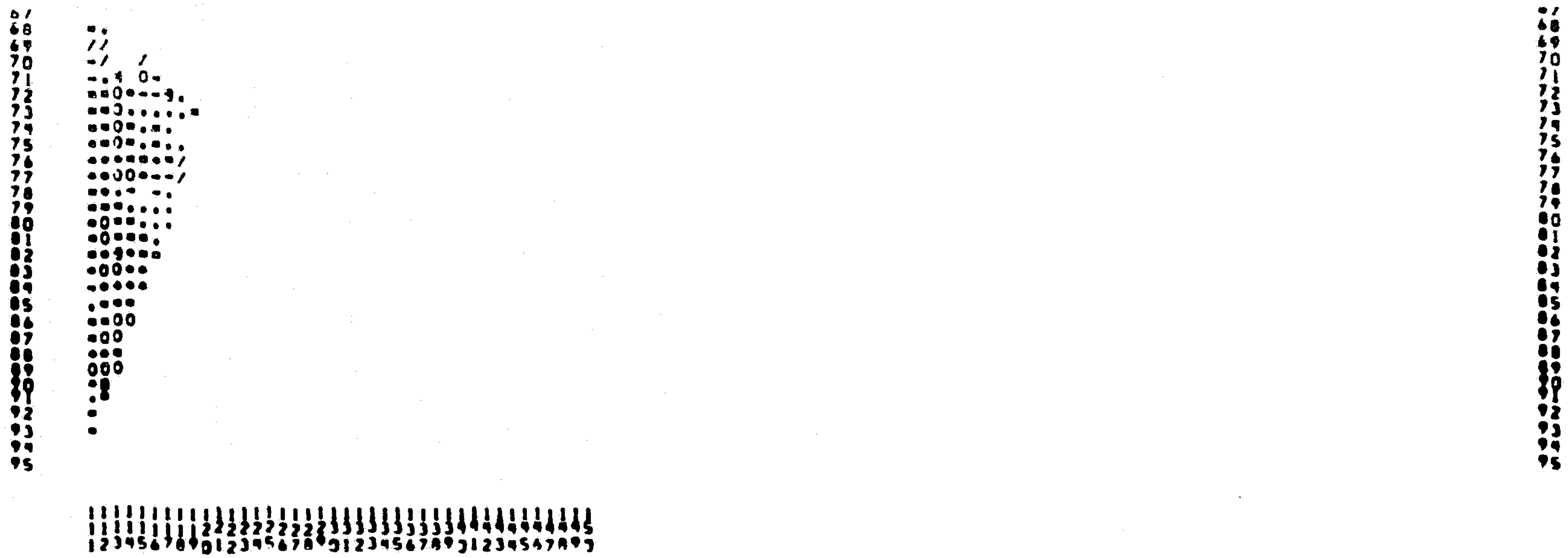


Figure 7-4.— Concluded.

8. STATISTICS PROCESSOR – STAT

The statistics processor STAT computes the multichannel means, standard deviations, covariance matrix, and correlation coefficient for each training field and all training subclasses which are defined through user input to the processor. In addition, at the user's option, histograms and spectral plots may be computed for each field and/or subclass.

The STAT processor requires user input of both punched cards and an MSS data tape (DATAPE). Card input consists of an optional number of cards from the set of control cards defined in table 8-1 and the training field definitions described in section 3.1.3. The required input MSS data must encompass the area of interest specified in the training field definitions. The processor is activated and initialized by a specific processor card defined in section 8.4.1. All processor functions which are available as options to the user are directed by means of the input control cards or the built-in defaults for any control card which is not input.

In addition to the optional printouts under the direction of the control cards, the STAT processor creates the output file SAVTAP, which contains the computed statistics (mean vector and covariance matrix) for each training subclass. The training subclass statistics optionally are output on punched cards (the module STAT deck). Both the output statistics file SAVTAP and the output module STAT deck are in a format acceptable to the statistics input requirements of other processors in the EOD-LARSYS. Figure 8-1 gives the functional flow of the STAT processor.

The mean vector for the *ith* subclass is computed as follows:

$$\mu_i = \overline{X}_{1i}, \overline{X}_{2i}, \cdots, \overline{X}_{pi}, \cdots, \overline{X}_{Pi} \tag{8-1}$$

where

$\overline{X}_{pi} = \frac{1}{N_i} \sum_{j=1}^{N_i} X_{pj}$ = average value in channel p for subclass i

p = channel number.

P = largest channel number.

N_i = number of samples in all training fields for subclass i.

X_{pj} = the *jth* sample of the MSS data for channel p (a value between 0 and 255).

μ_i = mean vector for the *ith* subclass.

The covariance matrix for the *ith* subclass is computed as follows:

$$K_i = \begin{bmatrix} k_{11i} & k_{12i} & \cdots & k_{1Pi} \\ k_{21i} & k_{22i} & \cdots & \\ \vdots & & k_{pqi} & \vdots \\ & & \vdots & \\ k_{P1i} & & \cdots & k_{PPi} \end{bmatrix} \tag{8-2}$$

where

$$k_{pqi} = \frac{1}{N_i - 1} \left[\sum_1^{N_i} X_p X_q - \frac{1}{N_i} \sum_1^{N_i} X_p \sum_1^{N_i} X_q \right]$$

q = channel number

Closely related statistics are the standard deviation and correlation coefficient for the *ith* subclass, which are computed as follows:

$$\left.\begin{aligned} \sigma_{pi} &= (k_{ppi})^{1/2} \\ \rho_{pqi} &= \frac{k_{pqi}}{(k_{ppi}k_{qqi})^{1/2}} \end{aligned}\right\} \qquad (8\text{-}3)$$

where

k_{pqi} = element of the covariance matrix for subclass i; the variance between channels p and q.

σ_{pi} = standard deviation in channel p for subclass i; p = q.

ρ_{pqi} = correlation coefficient between channels p and q for subclass i.

8.1 INPUT FILES

An MSS data tape (DATAPE) must be input to the STAT processor. The tape assignment defaults to logical unit C (Fortran unit 3); however, by input of the DATAFILE control card, the user may assign any available logical unit. (See table 4-1 for file assignments and section 3.2, MSS Image Data Tapes, for further information on format.)

8.2 OUTPUT FILES

The STAT processor always outputs the statistics on the SAVTAP file and, optionally (by means of the OPTION PUNCH control card), provides the module STAT deck. (See section 3.1.4.1 for format of card deck.) The only user action required for the card output is a notation on NASA/JSC form 588, which is submitted with the run deck, to the effect that punch-card output is being generated in the run.

The required output file SAVTAP will contain the class names, subclass names, and the subclass statistics (mean vector and covariance matrix) computed by the STAT processor for every subclass defined. The output statistics file must be assigned to either Fastrand or tape. The tape assignment defaults to logical unit A (Fortran unit 1); however, by input of the STATFILE control card, the user may assign any available unit. (See table 4-1 for file assignments and table 8-1 for control card description.)

Using the STATFILE control card the statistics from more than one execution of STAT may be saved on the same tape.

8.3 SCRATCH FILES

The STAT processor does not require the use of a separate scratch file.

8.4 CARD INPUT

The specific card column formats for the information to be input on the processor and control cards are given in sections 3.1.1 and 3.1.2. Table 8-1 describes the complete set of keywords and option parameters recognized and acted upon by the STAT processor.

If possible, each keyword and its option parameters are to be completely contained on one control card. However, if more parameters are required than can be contained on one card, the control card may be repeated and the parameters continued on the next control card. The parameters for a control card of a given type will be cumulative over all cards of that type.

The control cards follow the $STAT processor card. All options available on the STAT processor have a default setting which is used by the processor for those option parameters not input via control card. The control card *END* must be input to signify the end of the set of control cards. Immediately following the *END* card, a set or sets of class names, subclass names, and training field definition cards must be input. See section 8.4.4 for further details on training field definitions.

8.4.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$STAT

This card directs the system monitor routine to select the STAT processor and initiates the input of STAT processor control cards.

8.4.2 SPECIAL SYSTEM DECKS

The processor does not expect input of any of the system-generated card decks described in section 3.1.4.

8.4.3 CONTROL CARDS

Table 8-1 gives the complete set of control cards which the user may input to direct the STAT processor functions and the default functions performed by the processor. With the exception of the *END* and $END* control cards, the sequence of the control cards is optional. The *END* card must immediately follow the last control card, if any; the CLASSNAME, SUBCLASS name, and training field definition cards must immediately follow the *END* card; and the $END* card must immediately follow the last card of the input training field definitions.

8.4.4 CLASS, SUBCLASS, AND FIELD DEFINITIONS

All class, subclass, and field definition cards occur between the *END* and $END* control cards. The formats for these cards are given in section 3.1.3. Training fields are grouped into statistically similar subclasses, and subclasses are grouped further into classes.

A training class is defined to the processor by one card containing the keyword CLASSNAME in columns 1 through 9. The user-determined alphanumeric name to be assigned to the class begins in column 11 and may contain a maximum of six characters (through column 16). At least one CLASSNAME card must be input.

A CLASSNAME card must be followed by at least one subclass grouping. A subclass grouping is on a SUBCLASS card followed immediately by one or more field definition cards. All fields defined by field definition cards following the SUBCLASS card will contribute a cumulative sample set from which the training subclass statistics will be computed for the named subclass. The set of cards — one SUBCLASS card followed by one or more field definition cards — generates the statistics for one training subclass. The number of sets of SUBCLASS and field definition cards is determined by the number of sets of training subclass statistics. The number of training fields to be defined for one given subclass is not restricted. The following example shows the grouping of subclasses into classes.

Classes	Subclasses		
		$STAT	
		⋮ (Control cards)	
		END	
1		CLASSNAME	CLASS1
	1	SUBCLASS	SUB 11
		⋮ (Fields)	SUB 11 (of CLASS1)
	2	SUBCLASS	SUB 12
		⋮ (Fields)	SUB 12 (of CLASS1)
2		CLASSNAME	CLASS2
	3	SUBCLASS	SUB 21
		⋮ (Fields)	SUB 21 (of CLASS2)
3		CLASSNAME	CLASS3
	4	SUBCLASS	SUB 31
		⋮ (Fields)	SUB 13 (of CLASS3)
	5	SUBCLASS	SUB 32
		⋮ (Fields)	SUB 32 (of CLASS3)
	6	SUBCLASS	SUB 33
		⋮ (Fields)	SUB 33 (of CLASS3)
		$END*	

8.4.5 DECK SETUP

The STAT deck setup is given in figure 8-2. The @ in column 1 indicates the master punch for the Univac system, which is the 7-8 multipunch.

8.5 CARD OUTPUT

The STAT processor will optionally output on punched cards the module STAT deck (section 3.1.4.1). The module STAT deck contains the training field vertices, the subclass names for each training subclass, the subclass numbers assigned to each training subclass, the association of training fields to each subclass and class, and the computed statistics for each training subclass.

The module STAT deck is output by the processor only on demand specified by user input of the OPTION PUNCH control card.

8.6 SAMPLE COMPUTER RUNS

The sample computer run shown in figure 8-3 illustrates the output from the STAT processor using most available user options. The output was generated using a Hill-County-North data tape, 28 channels per scan line. Figure 8-4 is a program listing using only defaults.

In the first run (fig. 8-3), the options not used included NOCOVAR, HIST=F, COVAR=C, and COVAR=F. The NOCOVAR option would suppress all output normally obtained under the COVAR options. The HIST=F option would have displayed a histogram of all the fields. The COVAR=C option would print out the subclass statistics, whereas the COVAR=F option would print out the field statistics; the COVAR option generates the same output as these two combined. The typical output for a field or subclass is shown for each option illustrated. The run generated similar output for every field and every subclass defined.

The second run (fig. 8-4) demonstrates the use of all defaults. Output from this run is not shown.

8.7 RESTRICTIONS

The system-related restrictions in section 17 apply to the STAT processor.

In addition, a core storage limitation is associated with the total storage required by the training subclass statistics and the various options (i.e., producing histograms and spectral plots). The upper limit on core storage available for all requirements generated by the input to the STAT processor is 10 600 locations. Each subclass covariance matrix requires approximately 1/2(number of channels)^2 locations; each subclass mean vector requires locations equal to the number of channels; and each training field requires seven locations. If a large number of subclasses, channels, and training fields in combination with one or more of the options available by means of the OPTION control cards causes the core storage limits to be exceeded, the STAT processor prints a diagnostic message requesting the user to decrease options, after which it terminates execution (see section 8.8).

The following formula determines the maximum number of fields that can be input for a case without any histograms (eq. 8-4) and another case with subclass histograms (eq. 8-5).

$$\mathrm{NOFLD} = \frac{10\,600 - 5\mathrm{NOSPEC} + 7\mathrm{MAXSUB} + \left(\frac{4 + 2\mathrm{MAXSUB} + 5}{2}\mathrm{NOFEAT} + 1\right)\mathrm{NOFEAT} + 40}{32} \tag{8-4}$$

where

NOFLD = number of fields

NOSPEC = number of subclasses grouped together for spectrogram (maximum of 20)

MAXSUB = maximum number of subclasses

NOFEAT = number of channels

$$NOFLD = \frac{10\,600 - (5NOSPEC + 7MAXSUB + \left(\frac{4 + 2MAXSUB + 5}{2}NOFEAT + 1\right)NOFEAT + 40 + XSIZ}{32} \qquad (8-5)$$

If fields and subclasses need to be histogrammed, a value for XSIZ(NOHIST) + 1 should be added to the numerator of equation (8-5), where

XSIZ = range of histogram (maximum of 101)

NOHIST = number of channels histogrammed

8.8 DIAGNOSTIC MESSAGES

The diagnostic messages provided by the STAT processor are listed, along with probable cause and remedy of the condition which prompted the message. During statistical computations, other messages also may be output by utility routines common to both STAT and other processors in the EOD-LARSYS. See the system-related messages in section 6 for additional messages obtained from a STAT execution.

Message	Explanation
///// FROM SUBR. SETUP1 --- BAD CONTROL CARD ENCOUNTERED --- INPUT CARD IS ________, 'CCCC ... CCC'	The input card which was read has none of the legitimate keywords to identify it as a recognizable control card. The card which caused the message is printed out as part of the message. Although the processor will continue to

Message	Explanation
	read more control cards, this is an indication of an error in the deck setup. The deck should be checked for proper control cards and proper sequence of cards.
CHECK CHANNELS OR CLASS NOS. REQUESTED -- CANNOT BE LESS THAN OR EQUAL ZERO, OR GREATER THAN 30 ***** TERMINATING PROGRAM EXECUTION FROM SUBR. SETUP1 *****	If the channel numbers specified on a HISTO or CHANNELS control card are not integers within the range 1 through 30, this message results. The processor terminates execution after printing this message. Check the format of the applicable processor control cards (see section 3.1.2 and table 8-1).
/////FROM SUB. SETUP1 --- DECREASE OPTIONS ***** TERMINATING PROGRAM EXECUTION FROM SUBR. SETUP1 *****	The STAT processor has run out of internal storage to handle the combination of the quantities of input training fields, subclasses, and channels. Internal storage is fixed at 10 600 locations. Each subclass requires roughly 1/2(number of channels)^2 locations for the subclass statistics. If histograms or spectral plots of subclasses and/or fields are requested, additional internal storage is required. The options specified in the run deck (i.e.,

Message	Explanation
	histograms and spectral plots) and possibly the quantities of subclasses, channels, and training fields must be decreased or eliminated in order to get a successful run within the core storage limitation.
*** STAT/SETUP1 -- ERROR IN OPTION(S) REQUESTED - SCAN OF OPTION(S) DISCONTINUED AT CARD COLUMN XX ***	An OPTION control card is not acceptable to the processor. The scan of the options will be discontinued by the processor, and any options specified beyond the erroneous one will not be activated for the run. The processor continues with reading of the next control card. (See section 3.1.2 and table 8-1 for correct OPTION control card usage.)
***MAXSUB=XX --- MAX. NO. OF SUBCLASSES CANNOT BE GREATER THAN YY MAXSUB SET=YY PROCEEDING TO NEXT OPTION(S) ***	The maximum subclass number input on the OPTION MAXSUB control card exceeds the maximum number of subclasses that can be handled by the EOD-LARSYS. The processor will set the maximum number of subclasses, which will apply to subclasses read in from the input subclass/field definition deck.

Message	Explanation
***** STAT/LEARNN--MAX. OF XX SUBCLASSES EXCEEDED -- FIRST XX SUBCLASSES USED -- REMAINDER IGNORED	The processor has read the maximum allowable number of subclass names and training fields to be associated with each subclass, and the next subclass name encountered in the training field/subclass definition deck caused this diagnostic message. The first MAXSUB subclasses and associated training fields input are computed and the remainder are ignored by the processor.
***** STAT/LEARNN -- MAX. OF XX FIELDS EXCEEDED --- XX FIELDS RETAINED FOR YY SUBCLASSES ***** REMAINDER OF INPUT TRAINING FIELDS NOT USED	The STAT processor has read the maximum number of subclass names and associated training fields from the input training field/subclass definition deck. The available internal storage has been filled, and no further training fields can be accepted. Training statistics will be computed for the subclasses and fields which have been read to this point, and the remainder are ignored by the processor.

TABLE 8-1.— STAT PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
CHANNELS	$N_1, N_2, N_3, \cdots, N_k$ $1<k\leq 30$ Default: k=30; unless the MSS data tape (DATAPE) has exactly 30 channels, the default should not be taken.	N's are the integer channel numbers used by the processor in computing training subclass and training field statistics; must be from the set of channels available on the MSS DATAPE file.
OPTION	PUNCH Default: The module STAT deck is not punched, in which case statistics are output on the SAVTAP file only.	The subclass mean vector and covariance matrix for every subclass defined by user input will be punched on cards in a format acceptable as input to other processors in the system. This punched card deck is the module STAT deck defined in section 3.1.4.1.
OPTION	MAXSUB=N Default: MAXSUB=15	Informs the processor as to the maximum number of subclasses which will be input. The parameter value is used for dimensioning purposes and reflects the maximum number of available computer storage locations being utilized for other options allowed by the STAT processor. This parameter must be set by

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 8-1.— Continued.

Keyword	Parameter and default values	Function
		the user if the number of subclasses he is about to define will exceed the default. It is advisable to use this option when a large number of training fields are to be processed or when histograms have been requested.
OPTION	COVAR Default: Statistics are not printed.	The multichannel means, standard deviations, and covariance matrix (lower triangular portion) are printed out for each training subclass and training field defined in the input training field definition deck.
OPTION	COVAR=C Default: Statistics are not printed.	The multichannel means, standard deviations, and covariance matrix (lower triangular portion) are printed out for each training subclass defined in the input training field definition deck.
OPTION	COVAR=F Default: Statistics are not printed.	The multichannel means, standard deviations, and covariance matrix (lower triangular portion) are printed out for each training field defined in the input training field definition deck.

TABLE 8-1.– Continued.

Keyword	Parameter and default values	Function
OPTION	NOCOVAR	No training subclass or training field statistics are printed out.
HISTO	$N_1, N_2, N_3, \cdots, N_k$ $1<k\leq 30$ Default: k=30	N's are integers which provide a list of channel numbers for use in the histogram options. The channel numbers must be from the set designated on the CHANNELS control card. Note: This control card does not initiate the histogram option.
OPTION	HIST Default: No histograms	A histogram showing frequency distribution of pixels (resolution elements or radiance values) is printed out for every training field and every training subclass defined in the input training field definition deck. For each subclass (or field), a histogram is provided for every channel designated on the HISTO control card.
OPTION	HIST=C Default: No histograms	A histogram printout is provided for every training subclass defined in the input training field definition card. For each subclass, a histogram is provided for every channel

TABLE 8-1.– Continued.

Keyword	Parameter and default values	Function
		designated on the HISTO control card.
OPTION	HIST=F Default: No histograms	A histogram printout is provided for every training field defined in the input training field definition deck.
SIZE	XHIGH=K $0<K\leq 255$ Default: XHIGH=220	K is an integer which sets the maximum radiance value which will be histogrammed. XHIGH becomes X_{max} of the X-axis of the histogram plot.
SIZE	XLOW=L $0\leq L<XHIGH$ Default: XLOW=120	L is an integer which sets the minimum radiance value which will be histogrammed. XLOW becomes X_{min} of the X-axis of the histogram plot.
SIZE	YSIZ=J $0<J\leq f(x)_{max}$ Default: YSIZ=14	J is an integer which sets the number of increments on the Y-axis of the histogram plot; therefore, it is the height (number of print lines) of the Y-axis. Using the input YSIZ, the processor will determine the Y-axis scale for the histogram plot to be $f(x)_{max}+(YSIZ-1)/YSIZ$.
SIZE	XSIZ=K Default: XHIGH-XLOW	Sets the range which will be histogrammed; maximum range is 101.

TABLE 8-1.– Continued.

Keyword	Parameter and default values	Function
SPECTRAL	M_1, M_2, M_3, M_4 $1 \le M_i \le 30$ Default: 4 subclasses per spectral plot; subclasses 1, 2, 3, and 4 on the first plot; 5, 6, 7, and 8 on the second plot; etc.	M's are integers which provide a list of from one to four subclass numbers for the subclasses which are to be plotted on one single composite spectral plot. The subclass numbers must be obtained from the set of subclasses defined in the input training field definition deck. Subclass 1 is the first subclass defined in the deck, and subsequent subclass numbers are obtained by sequentially numbering the subclasses as they occur in the training field definition deck.
OPTION	SPECTRAL Default: Spectral plots for subclasses	A spectral plot is printed out for every training subclass and training field defined in the input training field definition deck. The plot consists of the subclass (or field) mean radiance value, mean standard deviation (σ), and mean $-\sigma$ plotted versus the channel (spectral band) for every channel designated on the CHANNELS control card.

TABLE 8-1.— Continued.

Keyword	Parameter and default values	Function
OPTION	SPECTRAL=C Default: Spectral plots for subclasses	A spectral plot will be printed out for every subclass defined in the input training field definition deck.
OPTION	SPECTRAL=F Default: Spectral plots for subclasses	A spectral plot will be printed out for every field defined in the input training field definition deck.
SIZE	SPECBAS=I $0 \leq I \leq 105$ Default: SPECBAS=75	I is an integer which sets the minimum radiance value on the Y-axis of the spectral plot (i.e., Y_{min}). The processor has a fixed Y-axis increment (3) and a fixed number of Y-axis values (50). Using SPECBAS, the processor determines the Y-axis range to be: Y_{min}=SPECBAS, Y_{max}=SPECBAS+150.
DATAFILE	UNIT=N,FILE=M Default: N=3,M=1	N is the Fortran logical unit number to which the MSS data tape (DATAPE) has been assigned; M is the file number on the tape to be processed. For back-to-back executions of several processors if the same file number is used, only one DATAFILE control card need be input.

TABLE 8-1.– Concluded.

Keyword	Parameter and default values	Function
STATFILE	UNIT=N,FILE=M Default: N=1,M=1	N is the logical Fortran unit number to which the SAVTAP file has been assigned; M is the file number on the tape to be processed.
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

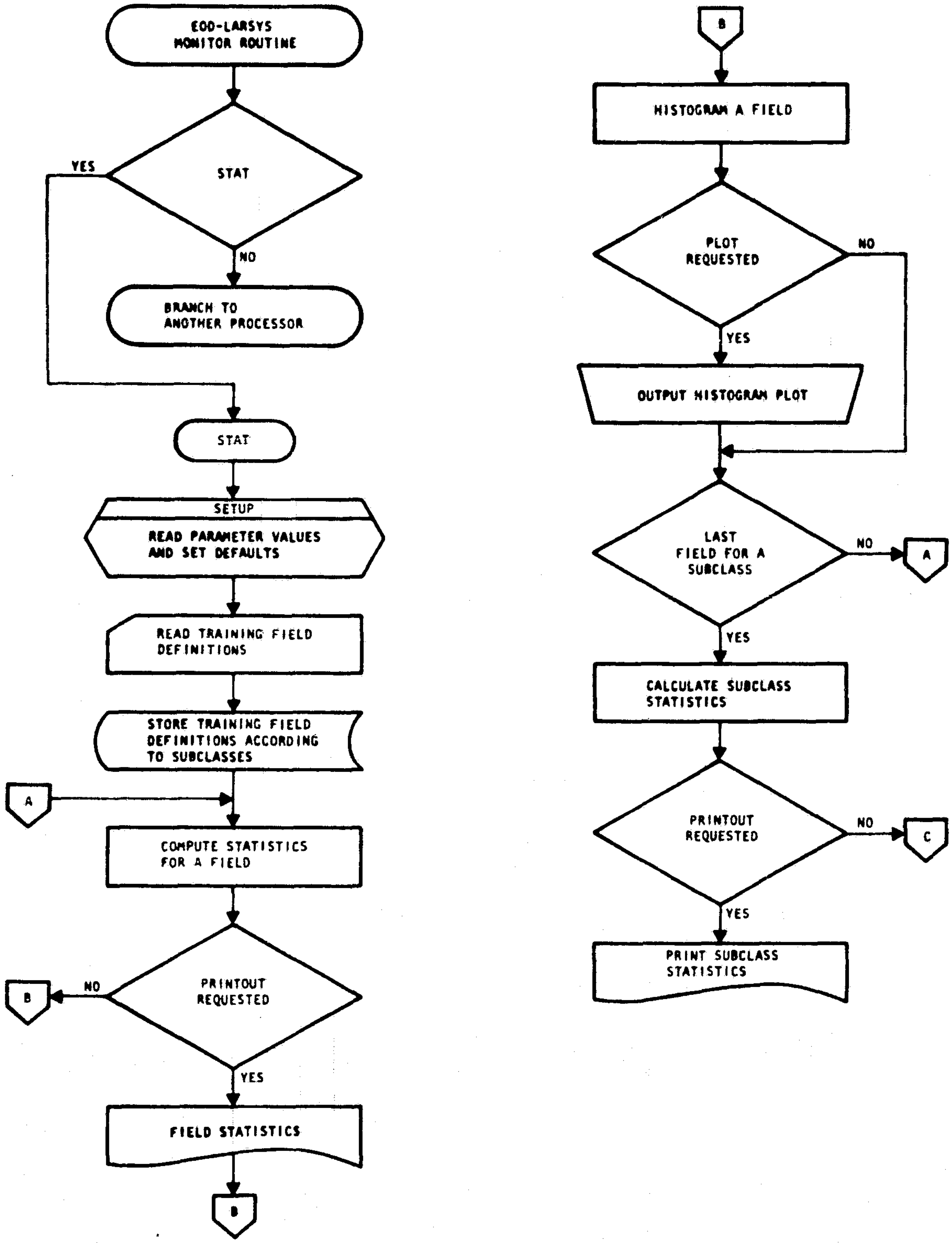


Figure 8-1.— Functional flow chart for the STAT processor.

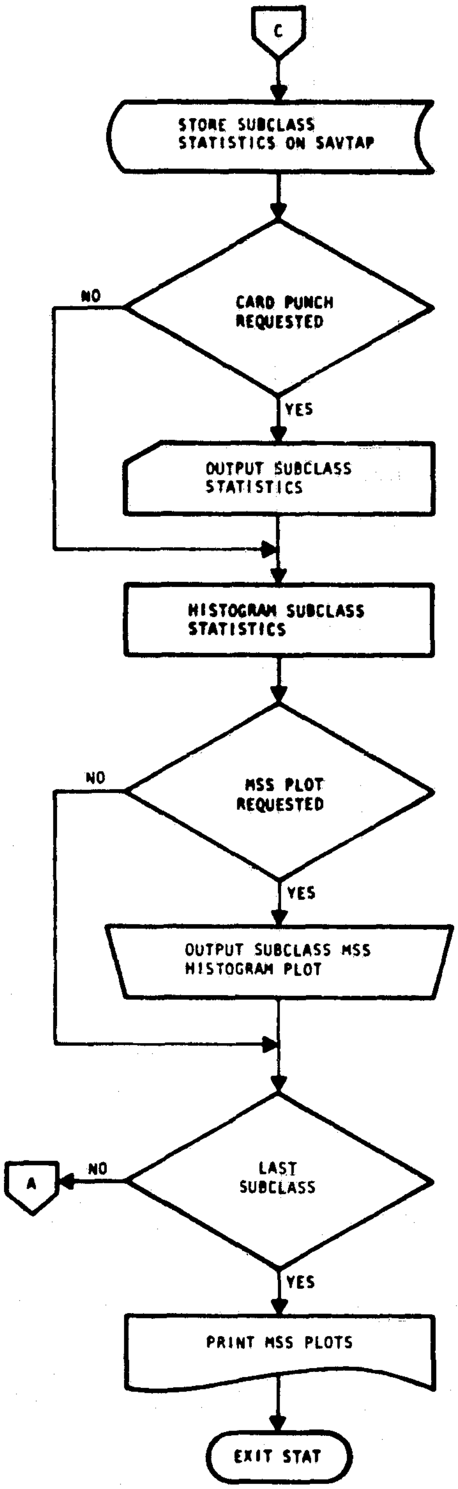


Figure 8-1.– Concluded.

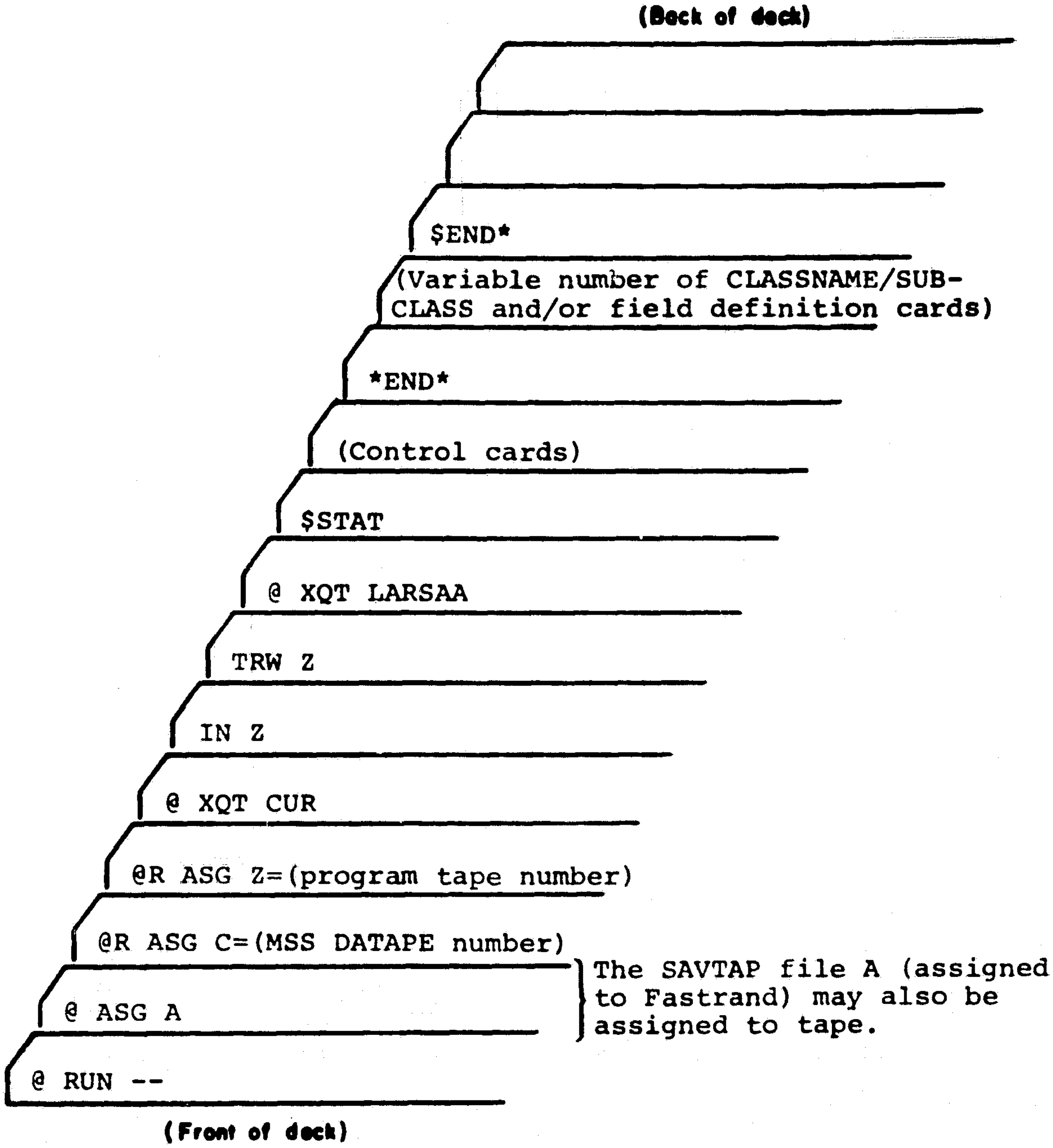


Figure 8-2.— Deck setup for the STAT processor.

Card	Sample program listing		Comment/command
1	@ RUN L78388,TF4,H4,1659,C087,C,20,2	CORBETT 4	EXEC 2 run card
2	@N MSG		EXEC 2 message card
3	@ ASG Z=V03795		Assign EOD-LARSYS program tape
4	@ ASG C=V07536		Assign MSS DATAPE
5	@ ASG A=V05230		Assign SAVTAP file to output tape
6	@ XCT CUR		Execute Univac tape complex utility routines
7	TRW Z		Rewind program tape
8	IN Z		Read program tape into system
9	TRW Z		Rewind program tape
10	@ XQT LARSAA		Execute EOD-LARSYS
11	$STAT		Execute STAT processor
12	COMMENT	STATS FOR HILL COUNTY	Comment used in heading printout
13	CHANNELS	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,	Channels to be used in STAT
14	CHANNELS	24,25,26,27,28	
15	HISTO	1,5,9,11	Channels to be used in the histogram options
16	OPTION	HIST=C	Histogram every subclass
17	SPECTRAL	10,12,28	Subclasses plotted on one single composite spectral plot
18	SPECTRAL	1,3,5,6	
19	SIZE	XHI=63,YSIZ=10,XLO=0,XSIZ=64,SPECRAS=5	Set scaling for histogram display and spectral plot
20	OPTION	COVAR	Print out statistics for every field and subclass
21	OPTION	MAXSUB=6	Set maximum number of subclasses to 6.
22	OPTION	PUNCH	Punch module STAT deck
23	OPTION	SPECTRAL=C	Print spectral plot for each subclass
24	OPTION	SPECTRAL=F	Print spectral plot for each field
25	HED1	*PHASE II*	Set the heading for printout
26	HED2	*LARSYS*	
27	DATE	8/27/75	
28	*END*		End of control card input
29	CLASSN	WHEAT	CLASSNAME card 1
30	SUBCLA	WW1	SUBCLASS card 1
31	W1-04	(1,1),(190,42),(204,42),(204,45),(190,45)	Training field definition 1, subclass 1
32	W1-01	(1,1),(319,62),(321,62),(321,81),(319,81)	Training field definition 2, subclass 1
33	W1-02	(1,1),(228,72),(231,72),(231,81),(228,81)	Training field definition 3, subclass 1
34	CLASSN	SUMWHT	CLASSNAME card 2
35	SUBCLA	SW1	SUBCLASS card 2
36	S1-01	(1,1),(258,40),(261,40),(261,57),(258,57)	Training field definition 1, subclass 2
37	CLASSN	SUMFAR	CLASSNAME card 3
38	SUBCLA	SF1	SUBCLASS card 3
39	F1-05	(1,1),(234,42),(241,42),(241,44),(234,44)	Training field definition 1, subclass 3
40	F1-02	(1,1),(292,62),(294,62),(294,81),(292,81)	Training field definition 2, subclass 3
41	F1-01	(1,1),(326,62),(331,62),(331,76),(326,76)	Training field definition 3, subclass 3
42	CLASSN	BARLEY	CLASSNAME card 4
43	SUBCLA	B1	SUBCLASS card 4
44	B1-02	(1,1),(292,51),(298,51),(298,60),(292,60)	Training field definition 1, subclass 4
45	CLASSN	GRASS1	CLASSNAME card 5
46	SUBCLA	GRASS1	SUBCLASS card 5
47	G1-01	(1,1),(178,50),(190,50),(19C,57),(178,57)	Training field definition 1, subclass 5
48	CLASSN	STUBBL	CLASSNAME card 6
49	SUBCLA	STUBBL	SUBCLASS card 6
50	ST-01	(1,1),(305,71),(316,71),(316,79),(305,79)	Training field definition 1, subclass 6
51	ST-02	(1,1),(244,75),(246,75),(246,80),(244,80)	Training field definition 2, subclass 6
52	ST-03	(1,1),(165,53),(177,53),(177,59),(165,59)	Training field definition 3, subclass 6
53	$END*		End of all input for STAT
54	$EXIT		Exit EOD-LARSYS
55	@F PMD		Give a core dump if run errs

Figure 8-3.– Sample program listing and output for the STAT processor using specified options.

```
$STAT
    COMMEN    STATS FOR HILL  COUNTY
    CHANNE    1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,
    CHANNE    24,25,26,27,28
    HISTO     1,5,9,11
    OPTION    HIST=C
    SPECTR    10,12,26
    SPECTR    1,3,5,6
    SIZE      XHI=63,YSIZ=10,XLO=0,XSIZ=64,SPECRAS=5
    OPTION    COVAR
    OPTION    MAXSUR=6
    OPTION    PUNCH
    OPTION    SPECTRAL=C
    OPTION    SPECTRAL=F
    HED1               *PHASE II*
    HED2               *LARSYS*
    DATE      8/27/75
    *END*
```


Figure 8-3.– Continued.

```
                    *PHASE II*
                    *LARSYS*                                                      8/27/75
        STATS FOR HILL   COUNTY

    YOU HAVE SELECTED THE FOLLOWING  $STAT  PROCESSOR OPTIONS:

        PRINT MEAN AND COVARIANCE FOR EACH FIELD
        PRINT SPECTRAL PLOT FOR EACH FIELD
        PRINT SPECTRAL PLOT FOR EACH SUBCLASS
        PUNCH MEAN AND COVARIANCE MATRIX FOR EACH SUBCLASS
        PRINT A HISTOGRAM  FOR EACH SUBCLASS
        PRINT MEAN AND COVARIANCE FOR EACH SUBCLASS


    SUPERVISOR INFORMATION:

       UNUSED CORE       34 LOCATIONS
       MAXIMUM NO. OF FIELDS..235
       MAXIMUM NO. OF SUBCLASSES...  6
       CHANNELS SELECTED ARE    1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15,
                               16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28,
       MULTISPECTRAL PLOTS ARE...
                                (10,12,28,   )
                                ( 1, 3, 5, 6,)

    INPUT IMAGE DATA TAPE INFORMATION

       FORMAT                    LARSYS 2
       NO. OF CHANNELS               28
       NO. OF PIXELS/LINE           381
       FIRST SCAN LINE NO.            1
       FIRST PIXEL REFERENCE PT       0
```

Figure 8-3.— Continued.

•PHASE II•
•LARSYS•

8/27/75

STATS FOR HILL COUNTY

TRAINING FIELDS

FIELD NO.	FIELD NAME	CLASS	SUBCLASS	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)			
1	WI-04	WHEAT	WW1	1	1	(190, 42)	(204, 42)	(204, 45)	(190, 45)
2	WI-01	WHEAT	WW1	1	1	(319, 62)	(321, 62)	(321, 81)	(319, 81)
3	WI-02	WHEAT	WW1	1	1	(228, 72)	(231, 72)	(231, 81)	(228, 81)
4	SI-C1	SUMWHT	SW1	1	1	(258, 40)	(261, 40)	(261, 57)	(258, 57)
5	FI-C5	SUMFAR	SF1	1	1	(234, 42)	(241, 42)	(241, 44)	(234, 44)
6	FI-02	SUMFAR	SF1	1	1	(292, 62)	(294, 62)	(294, 81)	(292, 81)
7	FI-G1	SUMFAR	SF1	1	1	(326, 62)	(331, 62)	(331, 76)	(326, 76)
8	BI-02	BARLEY	B1	1	1	(292, 51)	(298, 51)	(298, 60)	(292, 60)
9	GI-01	GRASS1	GRASS1	1	1	(178, 50)	(190, 50)	(190, 57)	(178, 57)
10	ST-01	STUBBL	STUBBL	1	1	(305, 71)	(316, 71)	(316, 79)	(305, 79)
11	ST-02	STUBBL	STUBBL	1	1	(244, 75)	(246, 75)	(246, 80)	(244, 80)
12	ST-03	STUBBL	STUBBL	1	1	(165, 53)	(177, 53)	(177, 59)	(165, 59)

Figure 8-3.– Continued.

PHASE II
LACSYS

8/27/75

STATS FOR HILL COUNTY

THE MEAN,STANDARD DEVIATION,COVARIANCE,AND CORRELATION (28 CHANNELS) FOR:

TRAINING FIELD #1-04

MEAN:	27.50	27.90	27.60	13.42	45.48	49.42	46.03	22.97	43.30	47.18	50.22	24.28
ST DEV:	1.07	1.13	1.37	.72	1.67	3.04	2.80	1.31	1.10	1.71	2.06	1.09
MEAN:	39.88	39.93	53.93	27.75	37.27	36.08	54.37	30.90	40.32	40.43	53.28	28.37
ST DEV:	1.41	2.67	1.94	1.45	1.88	3.21	1.98	2.05	5.17	7.44	2.53	1.59
MEAN:	43.40	50.75	52.10	25.52								
ST DEV:	1.71	2.61	2.63	1.56								

COVARIANCE MATRIX

1.14				
.46	1.28			
.71	.54	1.87		
.36	.21	.46	.52	
.16	.05	-.16	.10	2.80

Figure 8-3.— Continued.

.64	.72	.97	.20	1.85	9.26						
.39	.27	.49	.40	2.81	3.27	7.63					
.05	-.19	.12	.22	1.03	1.86	2.73	1.73				
-.12	.13	.00	-.08	-.08	-.62	-.01	-.23	1.40			
-.35	-.18	.33	-.04	.21	.26	1.33	.18	1.11	2.93		
.14	.02	.33	.31	.39	1.21	1.54	.67	.24	.67	4.24	
-.01	-.14	-.16	.12	.39	.51	.69	.23	.05	.25	1.51	1.19
-.11	-.03	.46	.13	.14	-.75	1.21	-.11	.58	1.04	.60	-.02
-.66	-.58	.29	-.21	-.66	-1.90	.82	-.19	.11	1.44	.29	-.20
-.00	.20	.06	.18	.88	1.84	1.76	.91	.24	.16	1.08	.68
.13	.06	.07	.12	.77	1.31	1.35	.72	.06	.10	.87	.51
.00	.62	-.11	-.08	-.57	-1.08	-2.57	-.86	-.13	-.76	-1.19	-.75
-.13	1.06	-.42	-.36	-1.31	.12	-4.56	-1.44	-.58	-1.47	-1.53	-.97
.07	-.01	.34	.34	1.18	1.79	2.65	1.49	-.01	.12	.63	.17
.41	-.21	.81	.48	1.41	2.64	3.90	2.05	-.22	.22	1.43	.57
-.16	-.63	-.04	.39	-.68	-4.05	-3.30	-2.77	.48	-.52	-2.22	.67
-.37	-1.07	.01	.26	-1.82	-4.68	-5.37	-4.24	.36	-1.00	-3.43	.65
.06	-.34	.18	.06	.03	-1.29	-.67	-.67	.08	-.73	-1.15	.29
.42	-.12	.27	.15	.67	1.12	1.85	1.27	-.23	-.25	.66	.03
.07	-.09	-.02	-.02	.07	1.17	.66	.34	-.51	-.45	1.44	.73
.36	.16	.29	-.03	.80	3.07	2.50	1.03	.25	.52	2.92	1.91
.36	.13	.40	-.01	1.14	3.33	2.08	1.43	.16	.46	2.72	1.17
.11	.19	.04	-.05	.58	2.04	1.41	.88	-.09	-.33	1.02	.53

2.58				
2.99	7.11			
-.18	-.95	3.76		
-.52	-1.56	2.03	2.09	
-.29	.12	-.78	-1.20	3.52

Figure 8-3.— Continued.

-1.36	-.74	-1.01	-1.37	4.54	10.28						
.16	-.04	1.26	.87	-1.37	-2.18	3.93					
.31	.03	1.72	1.25	-2.21	-4.18	2.63	4.19				
-.01	-1.91	-1.33	-.38	-.63	-2.96	-2.95	-1.59	26.69			
-.14	-2.32	-2.17	-.36	-1.64	-4.26	-4.47	-2.41	37.05	55.30		
-.19	-1.01	-1.03	-.93	.38	-.16	-1.16	-.34	5.69	12.65	6.38	
-.26	-.48	.46	.13	.09	.09	1.39	1.46	-4.59	-7.53	-.36	2.54
-.30	-.24	1.35	.90	-.38	.46	.02	.26	-1.71	-2.14	-.71	.34
-.32	-1.00	2.25	1.67	-1.76	-1.94	.25	1.00	-2.75	-3.06	-.81	.55
-.72	-1.76	2.94	2.11	-1.69	-1.87	.83	2.46	-3.81	-4.06	-.67	1.27
-.63	-1.27	1.56	1.10	-.43	-.37	.64	1.26	-1.86	-2.53	-.23	.84

2.92			
2.88	7.85		
2.40	5.75	7.99	
1.26	3.27	3.37	2.42

Figure 8-3.— Continued.

CORRELATION MATRIX

1.00											
.31	1.00										
.44	.35	1.00									
.38	.26	.46	1.00								
.10	.03	-.08	.00	1.00							
.20	.21	.23	.09	.36	1.00						
.13	.02	.13	.24	.60	.38	1.00					
.04	-.13	.07	.23	.47	.47	.74	1.00				
-.05	.10	.00	-.05	-.04	-.17	-.00	-.15	1.00			
-.19	-.10	.14	-.04	.08	.05	.28	.08	.55	1.00		
.07	.01	.12	.21	.11	.19	.27	.25	.10	.19	1.00	
-.01	-.11	-.10	.15	.21	.15	.22	.16	.09	.19	.67	1.00
-.06	-.02	.22	.12	.05	-.15	.27	-.05	.30	.38	.18	-.01
-.23	-.19	.08	-.11	-.15	-.23	.11	-.05	.03	.31	.05	-.07
-.04	.09	.02	.13	.27	.31	.33	.36	.10	.05	.27	.32
.08	.05	.03	.12	.32	.30	.33	.38	.03	.04	.29	.33
.00	.29	-.04	-.06	-.18	-.19	-.49	-.35	-.06	-.24	-.31	-.37
-.04	.29	-.10	-.15	-.24	.01	-.51	-.34	-.15	-.27	-.23	-.28
.03	-.01	.12	.24	.35	.30	.48	.57	-.00	.03	.15	.08
.19	-.05	.29	.33	.41	.47	.68	.76	-.09	.06	.34	.26
-.03	-.11	-.01	.11	-.08	-.26	-.23	-.41	.08	-.06	-.21	.12
-.05	-.13	.00	.05	-.15	-.21	-.26	-.43	.04	-.08	-.22	.08
.02	-.12	.05	.05	.01	-.17	-.09	-.20	.03	-.17	-.22	.11
.25	-.06	.12	.13	.25	.23	.42	.65	-.12	-.09	.20	.02
.34	-.05	-.01	-.01	.03	.22	.14	.15	-.25	-.15	.41	.39
.12	.05	.08	-.01	.17	.36	.32	.28	.07	.11	.50	.46
.12	.04	.10	-.00	.24	.39	.36	.38	.05	.09	.47	.38

Figure 8-3.— Continued.

.07	.11	.02	-.04	.27	.4[illegible]	.32	.43	-.[illegible]	-.1[illegible]	.32	.31
1.00											
.70	1.00										
-.06	-.18	1.00									
-.22	-.40	.73	1.00								
-.11	.07	-.71	-.44	1.00							
-.26	-.09	-.16	-.30	.75	1.00						
.05	-.01	.33	.30	-.37	-.34	1.00					
.11	.00	.43	.42	-.58	-.64	.65	1.00				
-.00	-.14	-.13	-.05	-.06	-.17	-.29	-.15	1.00			
-.01	-.17	-.15	-.03	-.12	-.18	-.30	-.16	.96	1.00		
-.05	-.15	-.21	-.25	.08	-.02	-.23	-.07	.74	.67	1.00	
-.15	-.11	.15	.06	.03	.02	.44	.45	-.56	-.44	-.09	1.00
-.14	-.05	.41	.36	-.12	.08	.01	.08	-.19	-.17	-.16	.13
-.07	-.13	.41	.41	-.33	-.22	.04	.28	-.19	-.15	-.11	.12
-.16	-.23	.54	.52	-.32	-.21	.15	.43	-.26	-.24	-.09	.28
-.25	-.29	.52	.49	-.15	-.37	.21	.39	-.23	-.22	-.06	.34
1.00											
.60	1.00										
.51	.72	1.00									
.48	.75	.77	1.00								

Figure 8-3.— Continued.

PHASE II
LARSYS

8/27/75

STATS FOR HILL COUNTY

SPECTRAL PLOT (MEAN,PLUS AND MINUS ONE STD. DEV.) FOR:

TRAINING FIELD #1-04

PLOT LEGEND:

\+ = FIELD #1-04

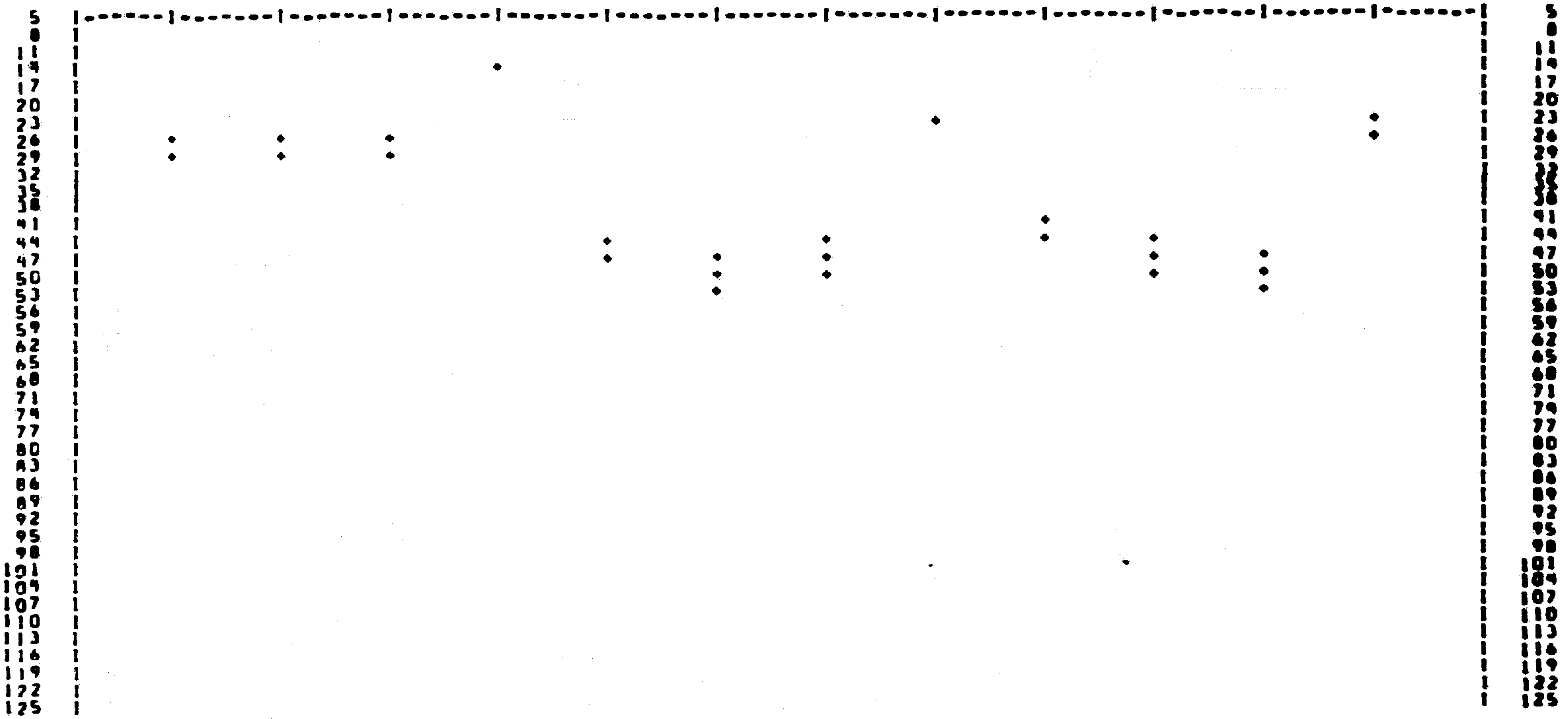


Figure 8-3.– Continued.

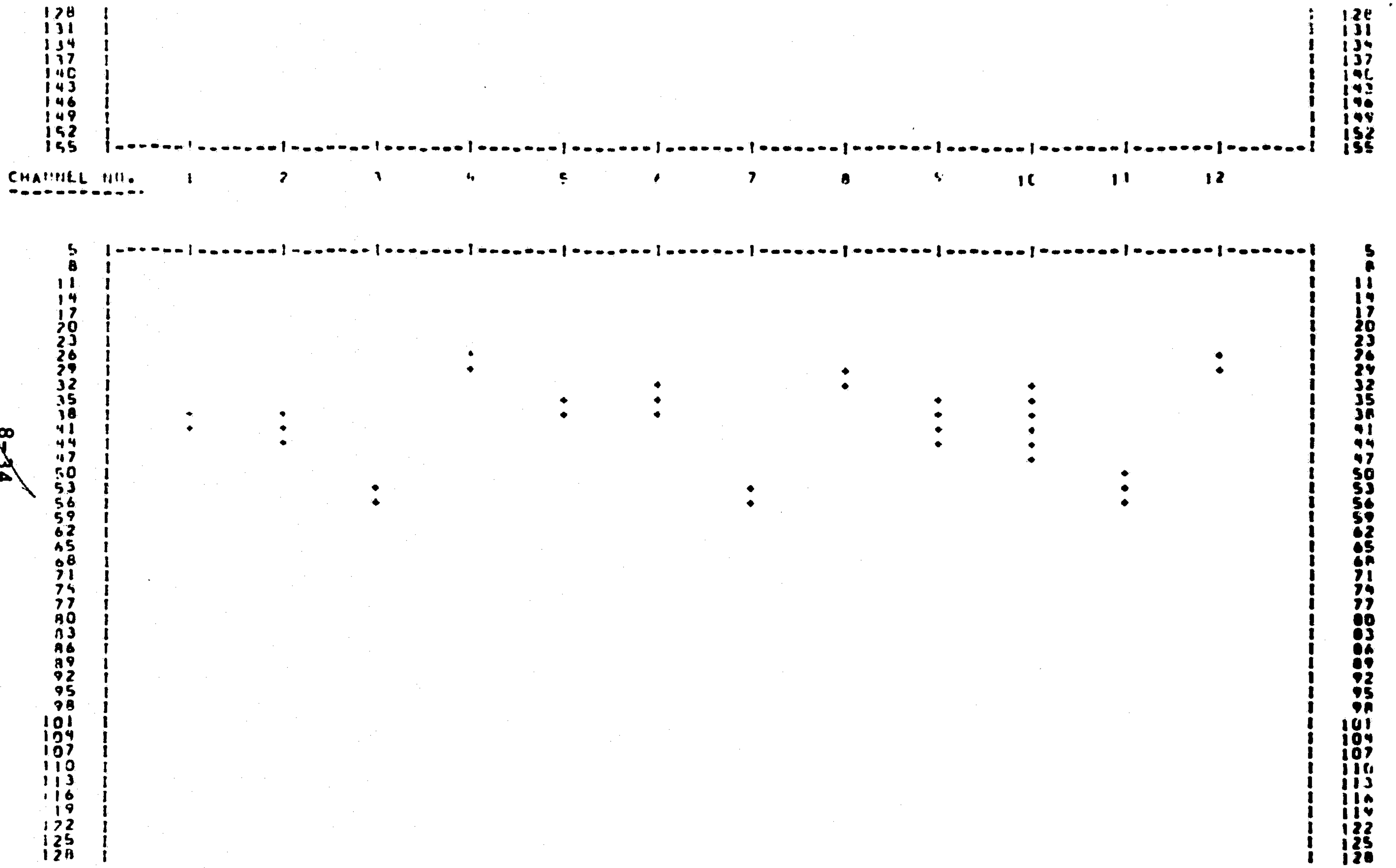


Figure 8-3.– Continued.

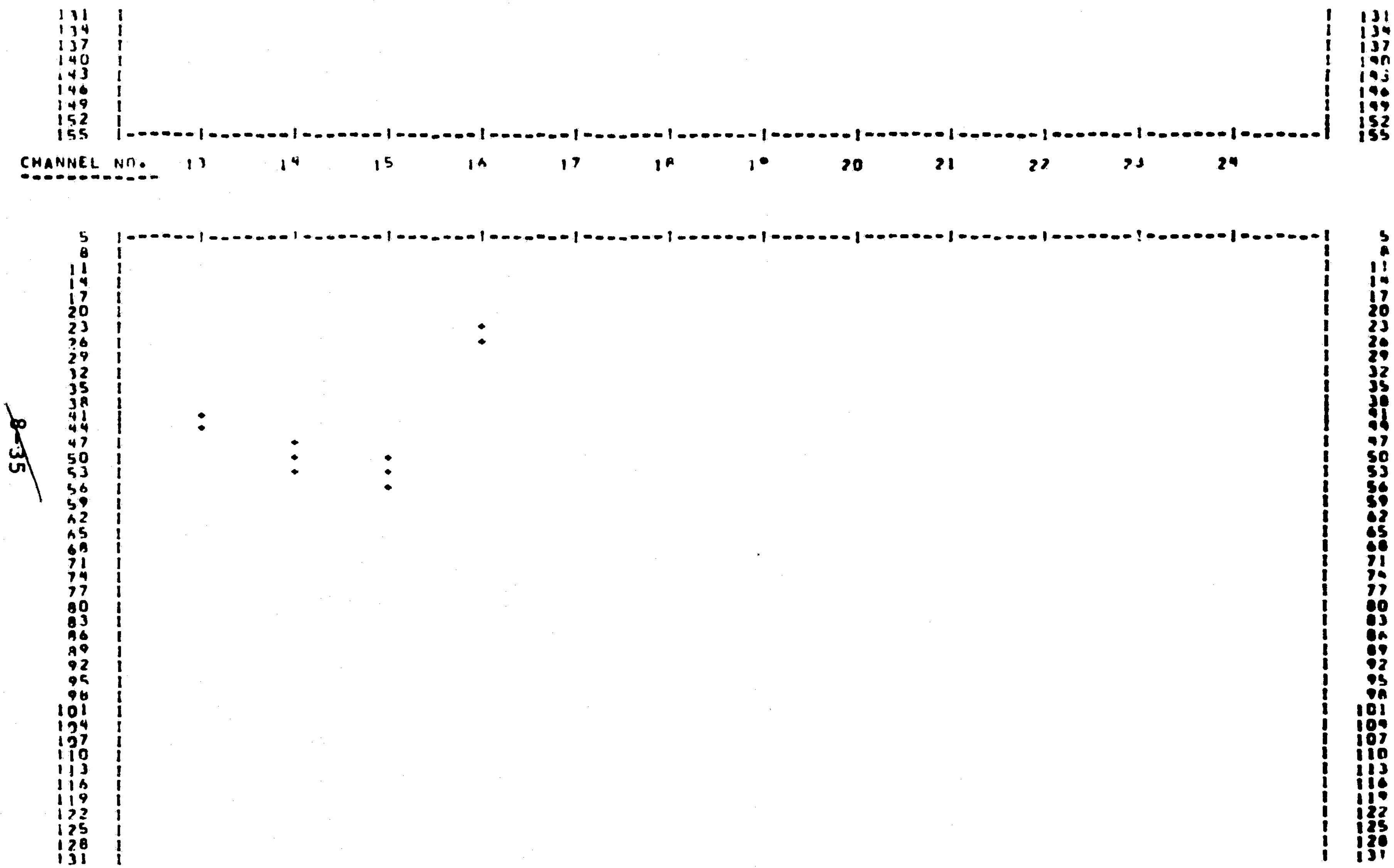


Figure 8-3.– Continued.

```
 134  I                                                                                                  I  134
 137  I                                                                                                  I  137
 140  I                                                                                                  I  140
 143  I                                                                                                  I  143
 146  I                                                                                                  I  146
 149  I                                                                                                  I  149
 152  I                                                                                                  I  152
 155  I-------'-------'-------I-------'-------I-------'-------I-------I-------I-------I-------I-------I  155
CHANNEL NO.   25      26      27      28
-----------
```

Figure 8-3.— Continued.

8/27/75

PHASE II
LAPEYE

STATS FOR HILL COUNTY

THE MEAN,STANDARD DEVIATION,COVARIANCE,AND CORRELATION (28 CHANNELS) FOR:

TRAINING SUBCLASS SF1

MEAN:	25.72	25.89	25.04	12.24	39.71	42.93	41.17	19.57	39.20	41.69	40.25	18.53
ST DEV:	1.21	1.45	1.69	.81	1.98	3.00	2.46	1.29	2.53	4.31	4.24	1.96
MEAN:	42.24	46.02	45.15	20.73	39.62	42.99	45.51	22.43	49.83	55.75	57.74	27.25
ST DEV:	1.96	2.35	2.53	1.30	3.24	5.98	3.88	2.84	7.20	10.86	4.10	1.34
MEAN:	41.37	45.34	43.01	19.37								
ST DEV:	1.81	2.07	2.20	1.34								

COVARIANCE MATRIX

1.46							
.98	2.11						
1.27	1.51	2.86					
.45	.66	.75	.66				
1.14	1.06	1.39	.52	3.91			
1.73	1.82	2.62	.81	4.76	9.47		
1.56	1.48	1.65	.76	3.14	4.53	6.06	
.74	.64	.99	.42	1.59	2.33	2.43	1.67

Figure 8-3.— Continued.

1.35	.56	1.37	.50	2.81	3.90	2.94	1.32	6.38			
2.13	2.65	2.50	.97	4.65	6.55	4.86	1.94	9.48	18.59		
2.14	2.66	2.55	1.96	4.93	7.30	5.31	2.11	9.19	16.87	17.97	
.84	.12	1.17	.52	2.24	3.49	2.29	1.01	4.17	7.26	7.51	3.85
-.11	.02	-.72	.00	.04	-.34	-.24	-.41	1.38	3.29	2.47	.69
.25	.16	.16	.07	.65	.54	.86	.47	1.98	4.55	3.29	1.31
-.01	.26	-.03	.02	.68	.60	.42	-.01	2.77	5.54	5.32	2.95
-.08	.15	.06	.65	.46	.63	.41	-.03	1.43	2.73	2.83	1.42
2.50	2.45	3.03	1.12	4.02	6.32	4.75	2.40	4.95	8.60	7.72	3.73
4.90	4.55	5.87	2.05	6.96	11.51	8.56	4.27	6.53	14.36	13.37	6.93
1.40	.93	1.78	.70	3.83	5.63	4.90	3.09	3.35	5.76	6.50	2.92
-.01	-.32	.11	.07	1.51	1.88	1.96	1.50	.81	1.42	2.18	.87
2.85	3.90	3.92	1.03	4.87	8.51	3.60	1.22	6.85	12.23	10.73	5.65
4.10	4.42	6.32	1.61	7.67	13.99	6.19	2.26	9.98	17.74	15.57	8.58
1.53	1.87	2.65	.55	2.73	4.86	2.92	1.37	3.77	6.92	5.71	3.23
.16	-.05	.20	-.07	.28	.24	.51	.53	.24	.72	.30	.21
.51	.44	.77	.38	1.41	2.31	1.07	.86	1.64	3.40	3.17	1.93
.53	.65	1.08	.38	1.35	2.66	1.23	.92	1.93	3.79	3.28	1.69
.90	1.08	1.95	.67	1.80	3.41	1.91	1.09	2.32	4.68	4.47	2.27
.60	.47	.77	.32	1.29	2.16	1.20	.72	1.10	2.06	2.15	1.09

3.85										
3.09	5.53									
3.17	3.43	6.41								
1.50	1.29	2.42	1.70							
-.11	1.48	1.02	.50	10.53						
-.33	2.46	1.72	.61	18.13	35.75					
-1.18	.58	-.53	-.07	4.23	5.71	15.06				
-.76	.09	-.54	-.14	-.67	-3.10	9.30	8.08			
4.27	1.52	6.53	3.13	17.74	25.06	-5.86	-9.92	51.77		
5.58	6.41	8.28	4.20	19.72	39.59	-8.81	-15.36	76.10	118.09	
2.28	2.68	3.34	1.65	7.37	13.70	-.04	-3.33	24.54	36.32	16.80

Figure 8-3.— Continued.

.10	.45	.31	-.22	.45	.80	1.51	.95	.57	.55	2.40	1.81
.68	1.30	1.30	.50	1.55	3.45	2.21	.97	3.49	5.48	2.44	.55
.98	1.62	1.31	.72	1.76	3.22	2.74	1.34	3.97	5.64	2.65	.35
.08	1.65	1.67	.91	3.45	6.54	2.57	.38	6.44	9.63	3.69	.53
.33	.65	.93	.40	1.79	3.72	1.59	.41	3.46	5.06	2.02	.31

3.29			
2.48	4.29		
1.91	2.42	4.86	
.89	.94	2.06	1.78

8-39
132

Figure 8-3.— Continued.

CORRELATION MATRIX

1.00											
.56	1.00										
.62	.62	1.00									
.46	.56	.54	1.00								
.48	.37	.42	.32	1.00							
.47	.41	.50	.37	.78	1.00						
.52	.41	.45	.38	.64	.60	1.00					
.47	.34	.46	.40	.60	.59	.76	1.00				
.44	.43	.32	.20	.56	.50	.47	.41	1.00			
.41	.42	.34	.28	.55	.49	.46	.35	.87	1.00		
.42	.43	.36	.31	.59	.56	.51	.38	.86	.88	1.00	
.36	.39	.35	.33	.58	.58	.48	.40	.84	.86	.90	1.00
-.05	.01	-.07	.00	.02	-.06	-.05	-.16	.28	.39	.30	.23
.09	.04	.04	.04	.14	.07	.15	.14	.33	.45	.33	.28
-.00	.07	-.01	.01	.14	.08	.07	-.00	.43	.51	.50	.49
[illegible]	.08	.03	.05	.18	.16	.13	-.02	.44	.49	.51	.55
.64	.52	.55	.43	.63	.63	.60	.57	.60	.61	.56	.59
.66	.52	.58	.42	.59	.63	.58	.55	.57	.56	.53	.55
.30	.17	.27	.25	.50	.47	.51	.62	.34	.34	.40	.38
-.00	-.08	.02	.03	.27	.22	.28	.41	.11	.12	.18	.16
.33	.29	.32	.18	.34	.38	.20	.13	.38	.39	.35	.40
.31	.28	.34	.14	.36	.42	.23	.16	.36	.38	.34	.40
.31	.31	.36	.17	.34	.39	.29	.26	.36	.39	.33	.40
.10	-.03	.09	-.07	.11	.06	.15	.31	.07	.04	.05	.08
.23	.17	.25	.26	.39	.41	.24	.37	.36	.43	.41	.40
.21	.22	.31	.23	.33	.42	.24	.34	.37	.42	.37	.40
.34	.34	.39	.38	.41	.50	.35	.38	.42	.49	.48	.53
.37	.24	.34	.30	.49	.53	.36	.42	.33	.36	.38	.41

1.00

Figure 8-3.— Continued.

.67	1.00										
.64	.58	1.00									
.59	.49	.73	1.00								
-.02	.19	.12	.12	1.00							
-.03	.18	.11	.08	.93	1.00						
-.15	.06	-.05	-.01	.34	.25	1.00					
-.14	.01	-.08	-.04	-.07	-.18	.84	1.00				
.30	.27	.36	.33	.55	.58	-.21	-.48	1.00			
.26	.21	.30	.30	.56	.61	-.21	-.50	.97	1.00		
.28	.28	.32	.31	.55	.56	-.00	-.29	.83	.82	1.00	
.04	.14	.09	-.01	.10	.10	.29	.25	.06	.04	.44	1.00
.19	.31	.28	.21	.31	.32	.31	.19	.27	.28	.33	.23
.22	.33	.25	.27	.26	.26	.34	.23	.27	.25	.31	.13
.20	.32	.34	.32	.48	.46	.30	.06	.41	.40	.43	.18
.13	.21	.26	.27	.41	.40	.31	.11	.36	.35	.37	.17

1.00			
.66	1.00		
.48	.53	1.00	
.37	.34	.71	1.00

Figure 8-3.— Continued.

8/27/75

PHASE II
LARSYS

STATS FOR HILL COUNTY

SPECTRAL PLOT (MEAN,PLUS AND MINUS ONE STD. DEV.) FOR:

TRAINING SUBCLASS SF1

PLOT LEGEND:

* = SUBCLASS SF1

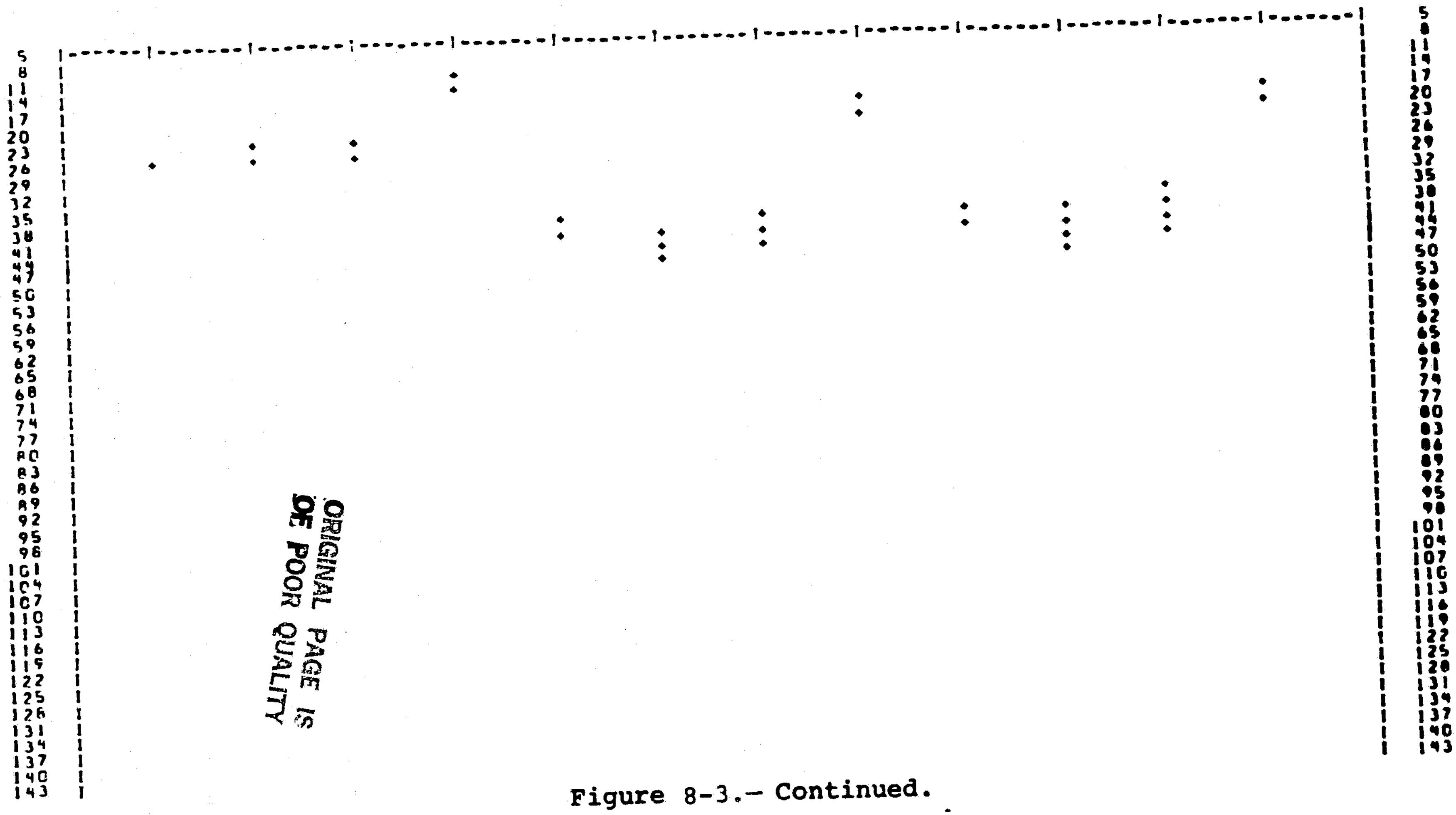


Figure 8-3.– Continued.

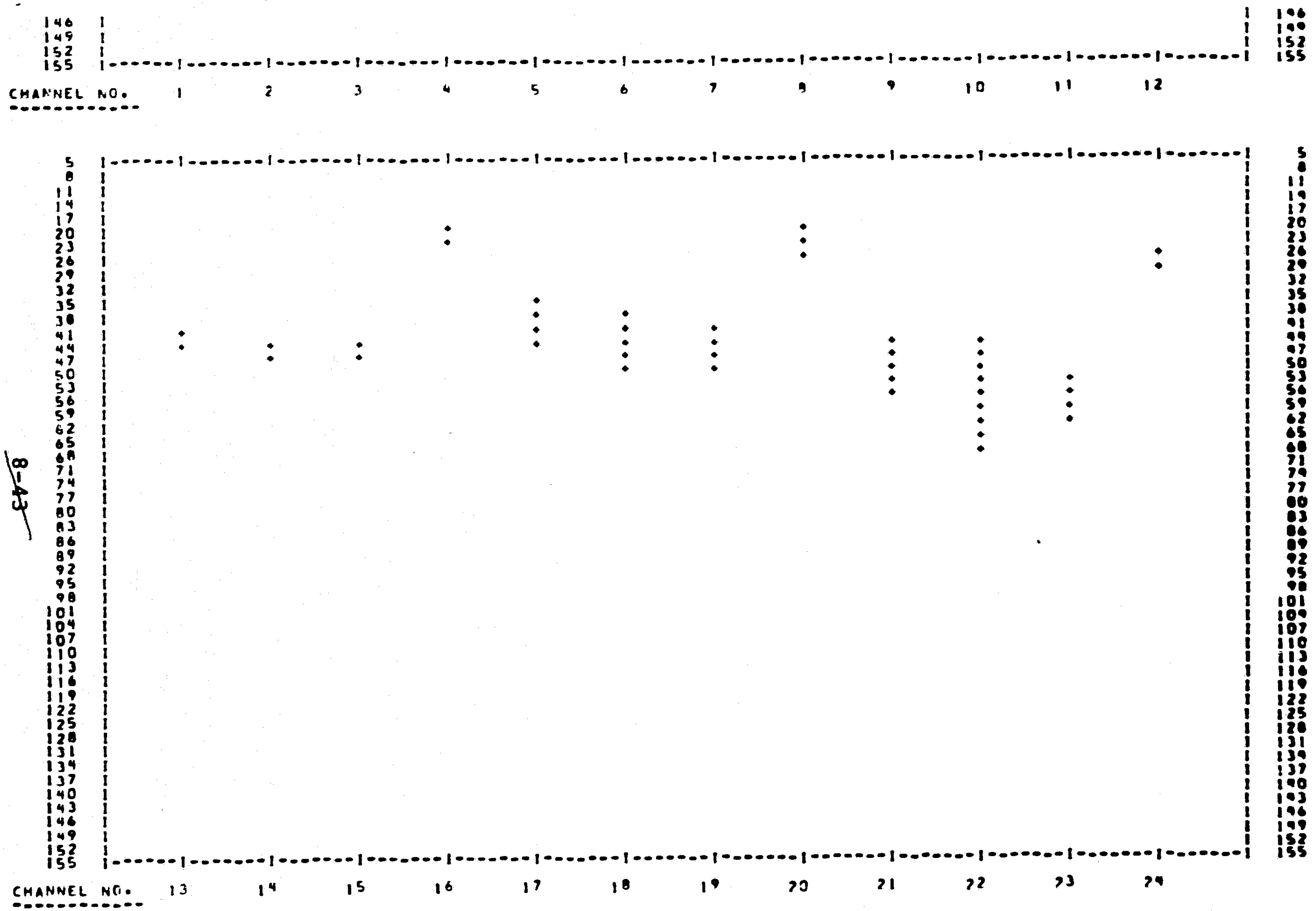


Figure 8-3.- Continued.

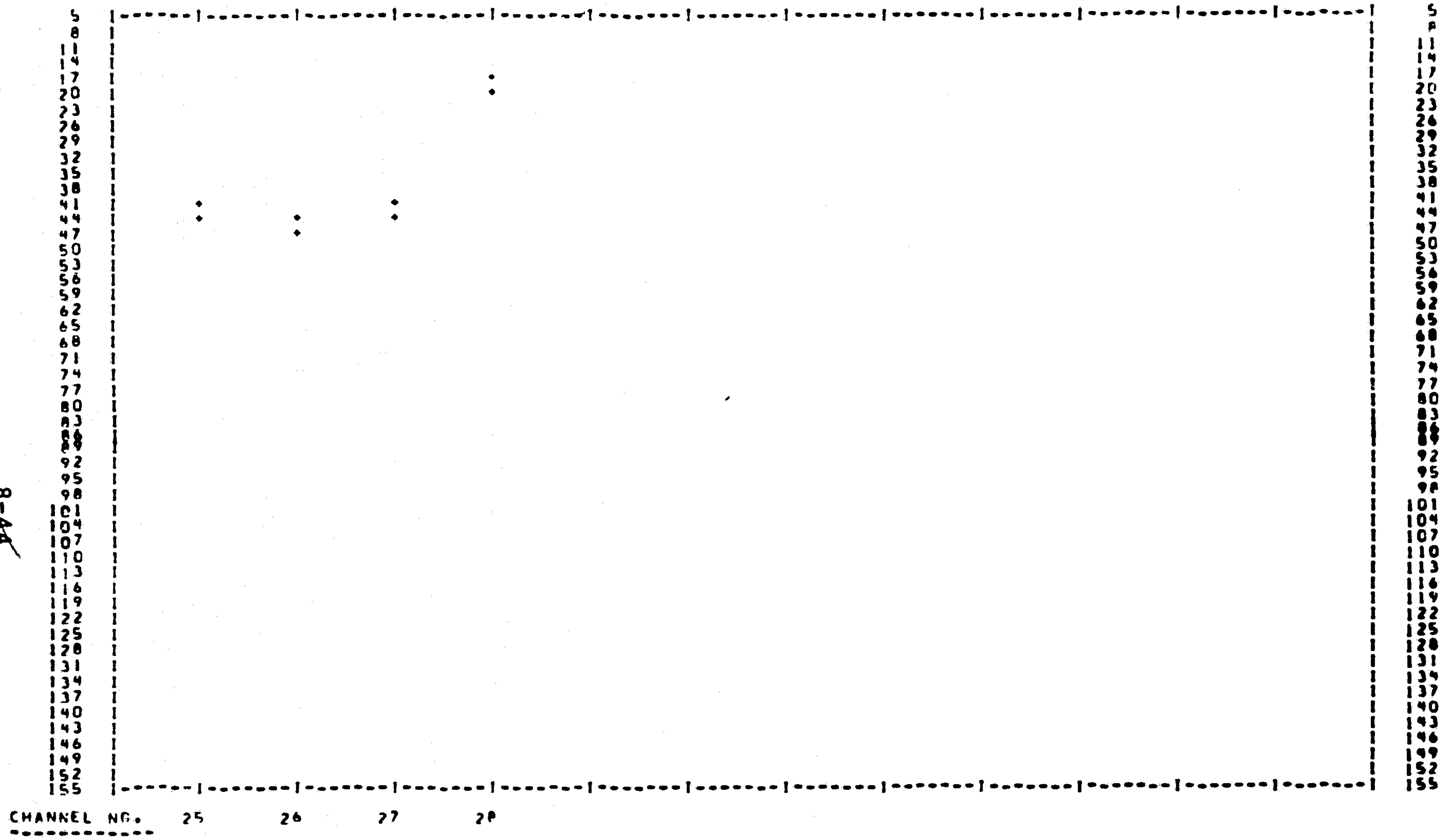


Figure 8-3.— Continued.

PHASE II
LARSYS

8/27/75

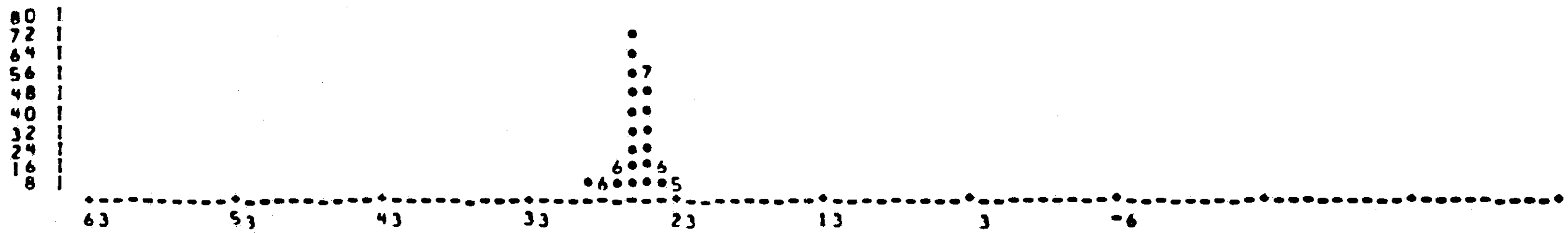
STATS FOR HILL COUNTY

HISTOGRAM

TRAINING SUBCLASS SF1

CHANNEL 1

EACH * REPRESENTS 8 POINT(S).



CHANNEL 5

EACH * REPRESENTS 5 POINT(S).

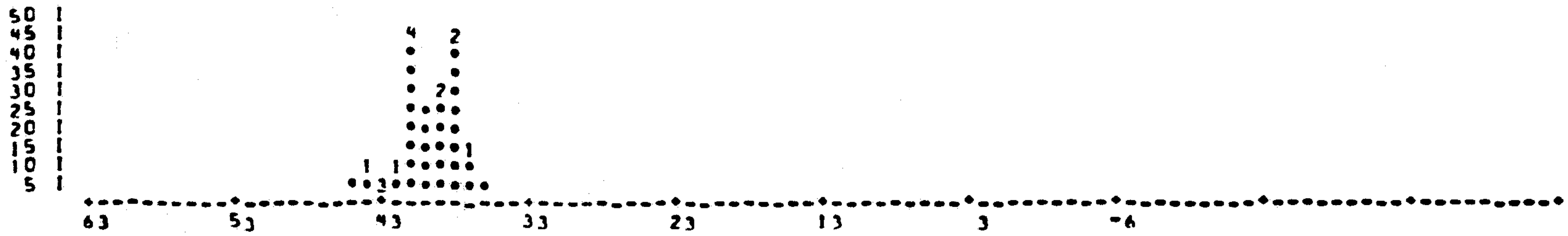


Figure 8-3.– Continued.

PHASE II
LAPSYS

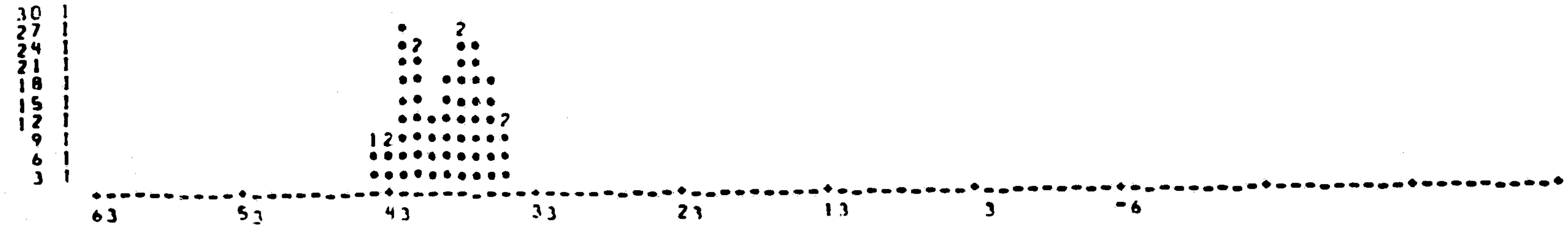
STATS FOR HILL COUNTY

HISTOGRAM

TRAINING SUBCLASS SF1

CHANNEL 9

EACH * REPRESENTS 3 POINT(S).



CHANNEL 11

EACH * REPRESENTS 3 POINT(S).

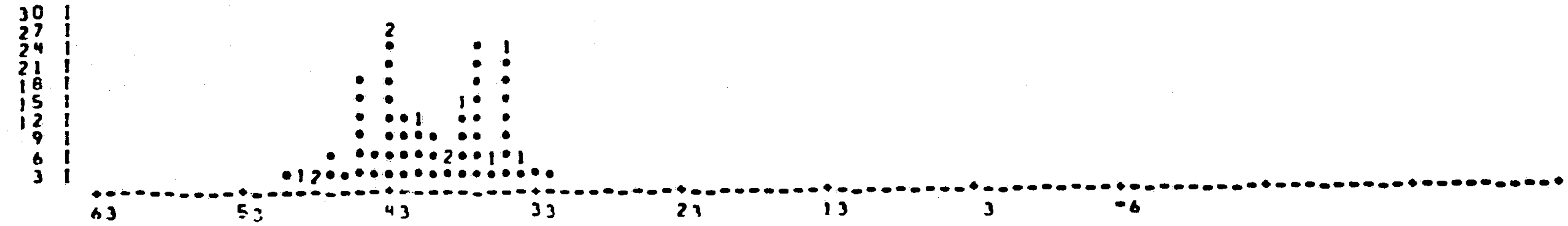


Figure 8-3.— Continued.

PHASE II
LARSYS

6/27/75

STATS FOR HILL COUNTY

COMPOSITE SPECTRAL PLOT (MEAN,PLUS AND MINUS ONE STD. DEV.) FOR:

TRAINING SUBCLASS(ES) 1 3 5 6

PLOT LEGEND:

$ = SUBCLASS WP1
+ = SUBCLASS SF1
■ = SUBCLASS GRASS1
● = SUBCLASS STUBBL

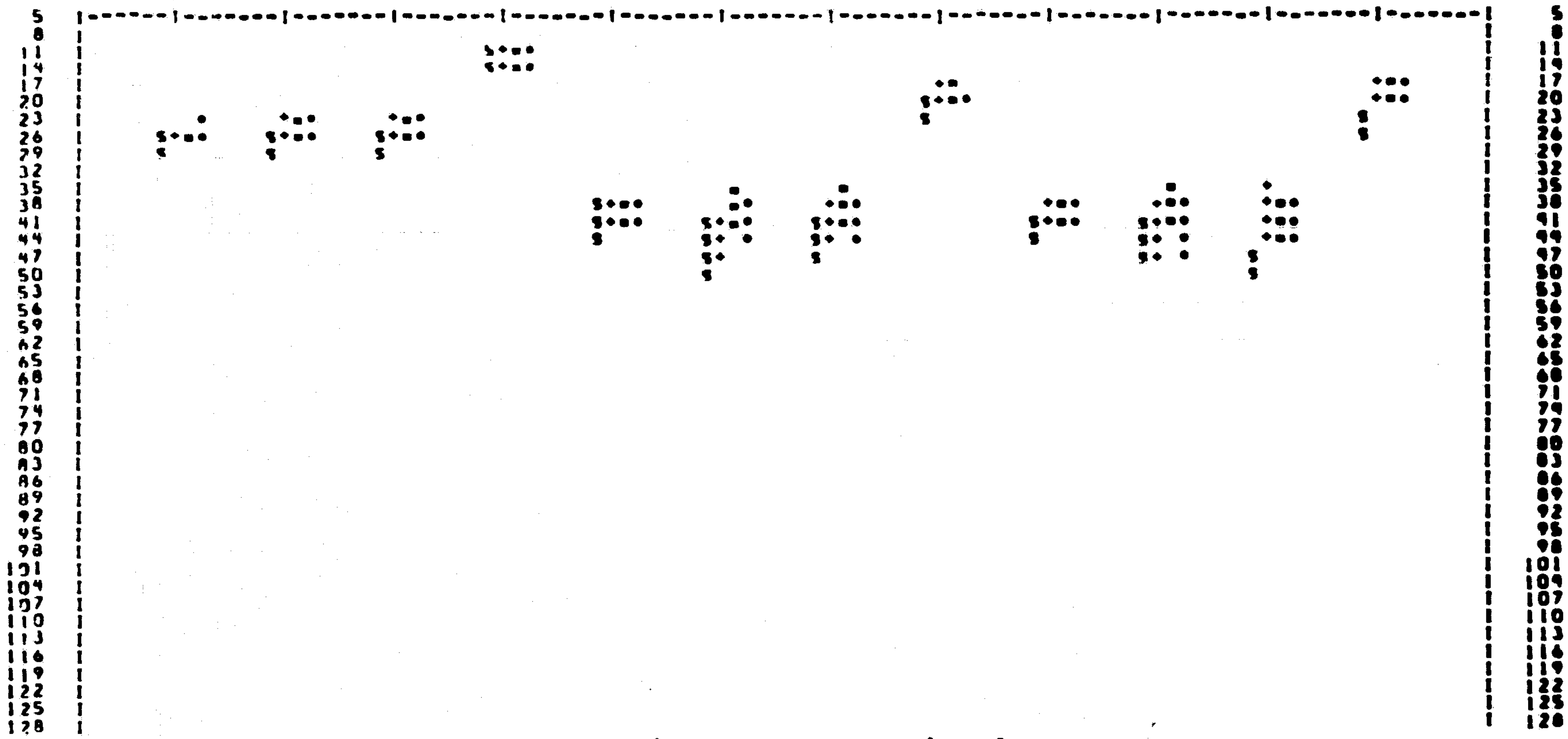


Figure 8-3.- Continued.

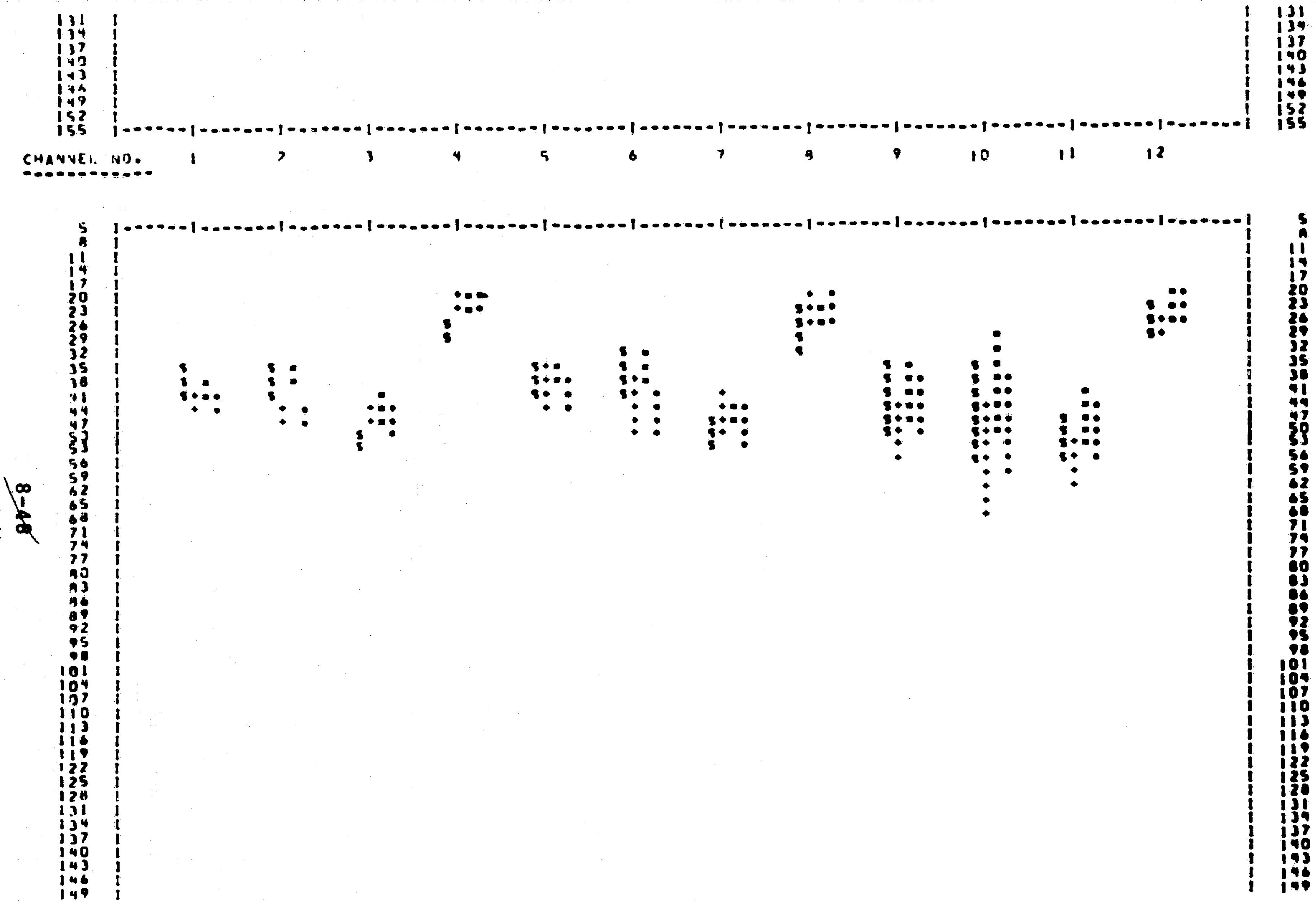


Figure 8-3.– Continued.

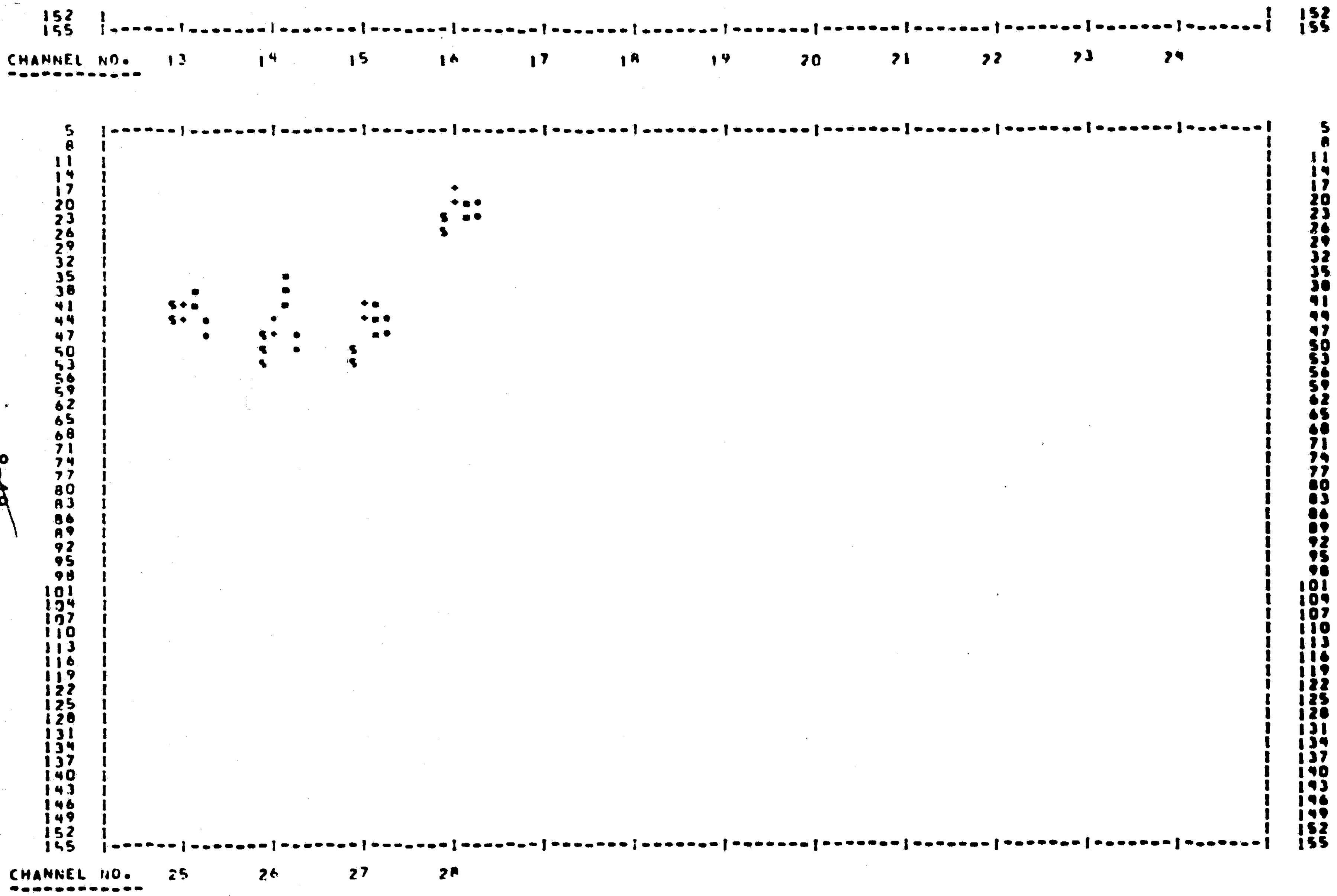


Figure 8-3.– Continued.

```
***  $STAT - COMPLETED  ***

TIME FOR STAT      2.076
```

Figure 8-3.- Concluded.

Card	Sample program listing		Comment/command
1	@Z RUN L78388,TF4,H4,1659,C087,C,10,5	CORBETT 39	EXEC 2 run card
2	@N MSG		EXEC 2 message card
3	@ ASG Z=VC3795		Assign EOD-LARSYS program tape
4	@ ASG C=VC7536		Assign MSS DATAPE
5	@ ASG A		Assign SAVTAP file to Fastrand
6	@ XQT CUR		Execute Univac tape complex utility routines
7	TRW Z		Rewind program tape
8	IN Z		Read program tape into system
9	TRW Z		Rewind program tape
10	@ XQT LARSAA		Execute EOD-LARSYS
11	$STAT		Execute STAT processor
12	COMMENT	STATS FOR HILL COUNTY	Comment used in heading printout
13	CHANNELS	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,	Channels used in STAT processor
14	CHANNELS	24,25,26,27,28	
15	*END*		End of control card input
16	CLASSN	WHEAT	CLASSNAME card 1
17	SUBCLA	WW1	SUBCLASS card 1
18	W1-34	(1,1),(190,42),(204,42),(204,45),(190,45)	Training field definition 1, subclass 1
19	W1-31	(1,1),(319,62),(321,62),(321,81),(319,81)	Training field definition 2, subclass 1
20	W1-32	(1,1),(228,72),(231,72),(231,81),(228,81)	Training field definition 3, subclass 1
21	CLASSN	SUMWHT	CLASSNAME card 2
22	SUBCLA	SW1	SUBCLASS card 2
23	S1-01	(1,1),(258,40),(261,40),(261,57),(258,57)	Training field definition 1, subclass 2
24	$END*		End of all input for STAT
25	$EXIT		Exit EOD-LARSYS
26	@F PMD		Give a core dump if the run errs

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Figure 8-4.– Sample program listing for the STAT processor using defaults.

9. ITERATIVE SELF-ORGANIZING CLUSTERING SYSTEM PROCESSOR — ISOCLS

A data set to be clustered by ISOCLS is defined by a class consisting of one or more fields from the MSS data tape (DATAPE). Any number of classes may be defined and clustered as individual data sets with one entry into the ISOCLS processor. The user has control over the maximum number of clusters allowed per class via the CLUSTERS control card. However, the procedure may find fewer clusters than the maximum allowed. If the user plans to use the statistics generated from the clusters in later CLASSIFY or SELECT runs, he or she must exercise control over the maximum number of clusters. The SAVTAP file may contain statistics for up to 75 clusters (or subclasses), but only 60 can be used for processing at any one time in CLASSIFY or SELECT. (Control cards are set out in table 9-1.)

The clustering procedure used in ISOCLS (ref. 3) is an iterative procedure which assigns each MSS data sample to a specific cluster by determining the nearest (in absolute distance) cluster center and assigning the sample to it. At the end of each iteration (i.e., when all samples have been assigned to a cluster), new cluster centers are defined by computing the mean vector for the data samples actually assigned to the cluster. After the initial split sequence, the iterative procedure terminates when the user-specified sequence of splits and combinations is exhausted. See the SEQUEN control card. The criteria for splitting or combining a cluster are user-specified by the STDMAX and DLMIN control cards.

After the final iteration, the covariance matrix for each cluster is computed and, at the user's option, is printed. All cluster statistics for the class are saved on a scratch file until all

classes have been clustered, at which time the SAVTAP file is written. The chaining of clusters for the final map printout is performed, if the user has requested the option (see CHAIN control card, table 9-1). Statistics for the chained clusters are not computed.

The processor allows the user to control the amount of line-printer output he receives via the KRN and MAP control cards. A final map of the clustered data is always output along with a statistical summary of the clusters, which includes mean and standard deviation vectors, total points assigned to each cluster, and intercluster distances.

Optionally the user may (1) input initial cluster centers to hasten the clustering process or (2) allow the program to initialize the process by assigning all the data to one cluster, obtaining the mean and standard deviation, and then splitting. Initial means may be input (1) by cards (see control card MEANS and Cluster Means Deck, section 3.1.4.3) or (2) by the SAVTAP file (see control card STATFILE). Input of the initial means causes a scratch file to be written so that the means can be used repeatedly. Successive classes may or may not use the same means to initialize cluster centers for a new class. The control card MEANS allows the user to request cluster centers from the last class to be read from the scratch file and used as initial centers for a new class. Input of a new set of initial means will cause the scratch file to be overwritten with new cluster centers.

See the functional flow chart for ISOCLS (fig. 9-1), which shows when each function is performed.

The clustering algorithm embodied in ISOCLS is detailed step by step in the following subsections. This entire procedure is repeated for each class (or data set).

9.1 PROCEDURES

9.1.1 NOTATION DEFINITIONS

Symbol	Fortran name	Definition
CLD_{ij}	CLD(I,J)	Intercluster distance between clusters i and j.
$d[X_k, \mu^{(i)}]$	DIST	Distance from the data point k to the center of cluster i.
DLMIN	DLMIN	Threshold value for combining clusters.
ISTOP	ISTOP	Maximum number of initial split iterations.
CHNTHS	CHNTHS	Chaining threshold value.
LNCAT	LNCAT INCAT	Number of existing clusters at a given time.
N(i)	N(I) DN(I)	Total number of data points assigned to cluster i.
SEQUEN	SEQUEN	User-specified sequence of split and combine iterations.
NMIN	NMIN	Minimum number of data points allowed per cluster for both the initial split iterations and for one through (NOSEQ-1) SEQUEN iterations.
PMIN	PMIN	Minimum of (PMIN+NOFEAT) number of data points allowed per cluster for the NOSEQ*th* SEQUEN iteration.

Symbol	Fortran name	Definition
NOSEQ	NOSEQ	Maximum number of SEQUEN iterations.
ISEQ	ISEQ	Number of SEQUEN iterations at a given time.
NOFEAT	NOFEAT	Number of coordinates (channels) in a data vector.
STDMAX	STDMAX	Threshold for splitting clusters.
X_k	C(I,K)	Data vector k, C(I,K)=$(X_1,X_2,\cdots,X_{NOFEAT})_k$
$\mu_j^{(i)}$	MEANS(J,I)	Mean of the *jth* coordinate of the *ith* cluster.
$\gamma_j^{(i)}$	AVP(J,I)	Temporary summing variable for the calculation of the standard deviation of the *jth* coordinate of the *ith* cluster.
$M_j^{(i)}$	AMN(J,I)	Summing variable for computation of new means. After all data have been assigned to clusters on each iteration, AMN(J,I) is the new mean of the *jth* coordinate of the *ith* cluster.
$\sigma_j^{(i)}$	STDEV(J,I)	Standard deviation of the *jth* coordinate of the *ith* cluster.

9.1.2 INITIALIZING THRESHOLD VALUES

Initialize threshold values for splitting clusters (STDMAX), combining clusters (DLMIN), and deleting clusters (NMIN and PMIN). Then begin the following iterative procedure.

9.1.3 ITERATIVE PROCEDURE

9.1.3.1 Classify and Calculate New Statistics

Assign each data point to a cluster and at the same time collect the means, standard deviations, and point counts of the newly developing clusters. If zero clusters, set $i = 1$ and go to iteration b. If more than zero clusters, go to iteration a.

a. Assign the data point $X_k = (X_1, X_2, \cdots, X_{NOFEAT})_k$ to the ith cluster if $d\left[X_k, \mu^{(i)}\right] \le d\left[X_k, \mu^{(j)}\right]$ for all $j \neq i$, where $d\left[X_k, \mu^{(i)}\right]$ is defined as

$$d[X_k, \mu^{(i)}] = \sum_{j=1}^{NOFEAT} \left| X_{jk} - \mu_j^{(i)} \right| \tag{9-1}$$

b. $$N(i) = N(i) + 1 \tag{9-2}$$

c. $$M_j^{(i)} = \frac{N(i) - 1}{N(i)} M_j^{(i)} + \frac{1}{N(i)} X_{jk} \tag{9-3}$$

d. $$\gamma_j^{(i)} = \frac{N(i) - 1}{N(i)} \gamma_j^{(i)} + \frac{1}{N(i)} X_{jk}^2 \tag{9-4}$$

e. $$\sigma_j^{(i)} = \left\{ \gamma_j^{(i)} - \left[\mu_j^{(i)}\right]^2 \right\}^{1/2} \quad ; \quad j = 1, NOFEAT \tag{9-5}$$

Return to step a and repeat iterations a through e until all data points have been classified.

9.1.3.2 Delete Clusters

For the initial split iterations and one through (NOSEQ-1) user-specified SEQUEN iterations, delete all clusters which have fewer than NMIN members. For the NOSEQ*th* user-specified iteration (last user-input sequence), delete all clusters which have fewer than PMIN members. A cluster is deleted simply by removing the statistics for that cluster and reducing the number of clusters (specified by LNCAT) accordingly.

9.1.3.3 Test for Completion

If this is not the last iteration, proceed to 9.1.3.4. If this is the last iteration and no clusters were deleted, the procedure is finished. If one or more clusters were deleted for having less than PMIN members, go back to 9.1.3.1 and reassign the data to the clusters obtained from iteration (NOSEQ-1).

9.1.3.4 Determine Type of Iteration

Determine whether this is to be a split iteration or a combine iteration and proceed to the appropriate step.

The sequence of iterations will be as follows:

$$\underbrace{\mathrm{SSSS}}_{\substack{\text{ISTOP} \\ \text{and/or} \\ \text{PERCENT}}} \quad \underbrace{\mathrm{CCSCSC}}_{\text{SEQUEN}}$$

where

S = split iteration

C = combine iteration

The beginning sequence of split iterations is terminated either (1) when the standard deviations for the user-input percentage of clusters (see PERCENT control card, table 9-1) are less than the STDMAX threshold parameter or (2) when ISTOP iterations have been reached. At that point, the type of iteration (split or combine) and number of iterations (NOSEQ) are determined by the SEQUEN parameter.

The initial split iterations are for the automatic initialization of cluster centers in the event they are not input. The sequence is shortened considerably if initial cluster centers are input.

9.1.3.5 Split Clusters

A cluster is split along the j*th* coordinate (1) if the j*th* coordinate has the maximum standard deviation for the cluster, (2) if the standard deviation along the j*th* coordinate is greater than the STDMAX threshold parameter, and (3) if the cluster has more than 2(NMIN+1) data points.

If conditions (1) through (3) are met, two new clusters are created and the parent cluster is deleted. A cluster is created merely by defining its centers (means) for each coordinate. If the i*th* cluster is split in the j*th* coordinate, the two new clusters will have centers at $\left[\mu_1^{(i)}, \mu_2^{(i)}, \cdots, \mu_j^{(i)} \pm \alpha, \cdots, \mu_{NOFEAT}^{(i)}\right]$, where α will normally be $\sigma_j^{(i)}$ but can be a user-input constant (see SEP control card). On a given split iteration, if the maximum number of clusters (CLUSTER) has not been reached, all clusters having a standard deviation greater than the STDMAX parameter will be split. To ensure that the clusters with the largest standard deviations receive the highest priority for splitting, when 2 × LNCAT > CLUSTER, the standard deviations are ordered along the j*th* coordinate in descending order. Return to 9.1.3.1 after splitting clusters.

9.1.3.6 Combine Clusters

Two clusters are combined if the distance between them is less than the DLMIN threshold parameter. The distance between clusters i and j is calculated as

$$CLD_{ij} = \left(\sum_{k=1}^{NOFEAT} \frac{\mu_k^{(i)} - \mu_k^{(j)}}{\alpha_k^{(i)} \alpha_k^{(j)}} \right)^{1/2} \qquad (9\text{-}6)$$

If CLD_{ij} < DLMIN and CLD_{ij} = MIN(CLD_{ij}) for all i = 1,LNCAT and j = 1,LNCAT for all i ≠ j, clusters i and j will be merged to form a new cluster L with means

$$\mu_k^{(L)} = \frac{N(i)\mu_k^{(i)} + N(j)\mu_k^{(j)}}{N(i) + N(j)} \quad ; \quad k = 1,\mathrm{NOFEAT} \qquad (9\text{-}7)$$

The clusters i and j are deleted. The new cluster L is not considered as a candidate for merging with any other cluster on the iteration in which it was formed. Return to 9.1.3.1 after combining clusters.

9.1.4 CHAINING

A final optional step in the clustering procedure groups all clusters which have intercluster distances less than the chaining threshold (CHNTHS) to form one cluster. The chaining procedure was adopted because the minimum variance criterion used in the iterative procedure above tends to group the data into spherical (or ellipsoidal) groupings with Gaussian distributions. This type of grouping is certainly a natural grouping and would quite often be completely satisfactory.

Some natural groupings of the data are odd shaped and cannot be approximated by Gaussian distributions. Two examples are given in figure 9-2. At the end of the sequence of split and combine iterations, groupings of the type in figure 9-2 are likely to be separated into subclusters as illustrated in figure 9-3. The chaining algorithm will indicate that the subclusters 1, 2, and 3 (fig. 9-3) could be grouped into one composite cluster; likewise, subclusters 4, 5, 6, and 7 could be grouped together to form one cluster.

The algorithm scans the intercluster distance table (CLD) and begins a chain with the first appearance of two clusters within a distance of CHNTHS units. Once a subcluster is in the chain, all clusters which are within CHNTHS units of the subcluster are added to the chain. See figure 9-4.

The statistics (means, standard deviations, and covariance matrices) of the clusters resulting from chaining are not calculated by the program because, in many cases, the chained cluster cannot be represented by a Gaussian distribution.

There are, of course, instances where one can safely combine those subclusters that are chained by the program into one composite (Gaussian) cluster. For example, subclusters 1, 2 and 3 in figure 9-5 can safely be combined into one final cluster. This is indicated by the fact that, pairwise, these three subclusters are all close to one another. In this case, the following formulas (ref. 3) can be used iteratively to compute the composite statistics.

Assuming that two clusters (n_1, m_1, C_1) and (n_2, m_2, C_2) are to be considered as one cluster (n, m, C), where all n, m, and C are the number of points, the mean vectors, and the covariance matrices, respectively, and m^T is the transpose of m then

$$\left.\begin{aligned}
n &= n_1 + n_2 \\
m &= \left(\frac{n_1}{n_1 + n_2}\right)m_1 + \left(\frac{n_2}{n_1 + n_2}\right)m_2 \\
C &= \left(\frac{n_1}{n_1 + n_2}\right)C_1 + \left(\frac{n_2}{n_1 + n_2}\right)C_2 + \left(\frac{n_1}{n_1 + n_2}\right)m_1 m_1^T \\
&\quad + \left(\frac{n_2}{n_1 + n_2}\right)m_2 m_2^T - mm^T
\end{aligned}\right\} \qquad (9\text{-}8)$$

9.2 INPUT FILES

An MSS data tape (DATAPE) must be input to the ISOCLS processor. The tape assignment defaults to logical unit C (Fortran unit 3); however, by input of the DATAFILE control card, the user may assign any available logical unit. (See table 4-1 for file

assignments and section 3.2, MSS Image Data Tapes, for further information on format.)

9.3 OUTPUT FILES

Statistics are output by ISOCLS to the SAVTAP file (section 4.1). The logical unit must be assigned either to tape or to Fastrand for this file. The file should be output to tape and saved if the statistics may be required for further analysis in later runs. Multiple files may be saved on the same tape. The tape assignment defaults to logical unit A; but, by input of the STATFILE control card, the user may assign any available logical unit. (See table 4-1 for file assignments and STATFILE control card, table 9-1, for further information.)

A cluster map tape (MAPFIL) may be generated optionally for displaying the results of the clustering on the Bendix 100 or the PMIS DAS. The FORMAT control card initiates the option and names the desired format of the tape. Logical unit N (Fortran unit 16) should be assigned to a nine-track tape drive when this option is exercised (see section 5.1).

9.4 SCRATCH FILES

The program dynamically assigns random access drum storage for scratch files. ISOCLS uses the drum storage for temporary storage of cluster statistics, the data to be clustered, and the classification of each pixel.

9.5 CARD INPUT

9.5.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$ISOCLS

This card directs the monitor routine to call the ISOCLS processor and causes all routines used by the ISOCLS processor to be loaded into the system.

9.5.2 SYSTEM CARD DECKS

The processor will read a cluster MEANS deck in the format defined in section 3.1.4.3. The deck may be used to initialize cluster centers for the clustering procedure.

9.5.3 CONTROL CARDS

Control cards allow the user to input various options. They are identified by a keyword that is left justified in columns 1 through 10 of the card, with parameter values or additional keywords in columns 11 through 72. These control cards may be in any order, but they must be the first cards after the processor card $ISOCLS. Table 9-1 lists all available options, along with their parameter values.

9.5.4 CLASS AND FIELD DEFINITIONS

A CLASSNAME card, followed by at least one field definition card, must immediately follow the *END* control card. The formats for these cards are defined in section 3.1.3.

The pixels from all fields for one class are extracted from the MSS data tape (DATAPE) and stored on a high-speed drum file. The data from all fields for one class are clustered as one data set. The statistics for all clusters in that class are saved on a scratch file, and the next class is clustered. When all classes have been clustered, the statistics are written on the SAVTAP file (see appendix H for sample execution). The SETUP routine may be entered after each class to change parameter values. The input for definition of classes and fields is explained below.

```
Write the SAVTAP file              $ISOCLS
after five classes have            CLASSES    5
been clustered.
                                     :  (Other control cards)

                                   *END*
WHEAT 1 clustered as               CLASSNAME           WHEAT1
one data set.                      FIELD1
                               1   FIELD2
                                   FIELD3
                                   CLASSNAME           WHEAT2
                               2   FIELD4
Enter SETUP routine                FIELD5
again for new parameter            $END*
values.
                                     :  (New parameter values)

                                   *END*
                                   CLASSNAME           NONWH1
                                   FIELD6
                               3   FIELD7
                                   FIELD8
                               4   CLASSNAME           NONWH2
                                   FIELD9
                               5   CLASSNAME           NONWH3
                                   FIELD10
Now write statistics               $END*
file.                              $(Next processor)
```

9.5.5 DECK SETUP

The deck setup for the ISOCLS processor is given in figure 9-6; ISOCLS may be run independently, as shown in (a), or back to back with CLASSIFY and DISPLAY, as shown in (b). The @ in column 1 indicates the master punch for the Univac system, which is the 7-8 multipunch.

9.6 CARD OUTPUT

A module STAT deck (see section 3.1.4.1) may be punched and used as an interface between ISOCLS and SELECT or CLASSIFY. This option is exercised via the OPTION PUNCH control card.

9.7 SAMPLE COMPUTER RUNS

The two computer listings in figures 9-7 and 9-8 demonstrate, respectively, the use of all defaults and the use of all options for the ISOCLS processor.

Run 1 (fig. 9-7) uses all defaults except CHANNELS and clusters a large data set from flight line C-1. The data set is given the class name ALL, and it will have a maximum of 60 clusters. The SAVTAP file will have only one class. Therefore, if it is used in CLASSIFY, categories cannot be defined inasmuch as the standard classifier would be used. Output from run 1 is not shown.

Run 2 (fig. 9-8) demonstrates the use of all options in ISOCLS. Training fields for two classes are clustered, producing 20 clusters for class WHEAT and 20 clusters for class NONWH.

Run 3 (fig. 9-9) demonstrates the use of most options in ISOCLS. A LACIE segment is clustered and the image output to a file in Universal format.

9.8 RESTRICTIONS

The ISOCLS processor uses the FH432 and FH1782 drums for temporary scratch files. There are approximately 1 310 000 words of storage available on these drums. The data to be clustered for one class are stored on this file, along with other information. To compute the maximum number of pixels per class, use the following formula.

$$\text{Maximum pixels} = \frac{1\ 310\ 000 - 30\left\{\begin{matrix}\text{number of}\\ \text{classes}\end{matrix}\left[\left(\begin{matrix}\text{number of}\\ \text{channels}\end{matrix}\right)^2 + 3\left(\begin{matrix}\text{number of}\\ \text{channels}\end{matrix} + 2\right)\right] - 1800\right\}}{\text{number of channels} + 1} \tag{9-9}$$

The maximum number of clusters per class is 60, and the maximum number of channels is 30. The covariance matrices for all clusters in one class must be stored in core at one time. They are stored in an array dimensioned 11 500. The following formula may be used to see if enough storage is available for the covariances.

$$11\ 500 \geq \begin{matrix}\text{number of}\\ \text{clusters}\end{matrix}\left[\begin{matrix}\text{number of}\\ \text{channels}\end{matrix}\left(\frac{\begin{matrix}\text{number of}\\ \text{channels}\end{matrix} + 1}{2}\right)\right] \tag{9-10}$$

9.9 DIAGNOSTIC MESSAGES

Message	Explanation
CHANNELS CANNOT BE CHANGED UNTIL THIS EXECUTION OF ISOCLS IS COMPLETED.	The channels to be used should be set in the first set of control cards input after the ISOCLS card. That set of channels will be used for all classes. If the user attempts to input a CHANNELS card into the SETUP routine on a later entry, the card will be ignored.

Message	Explanation
NO. OF CLASSES CANNOT BE CHANGED UNTIL THIS EXECUTION OF ISOCLS IS COMPLETED.	The number of classes to be clustered must be input only in the first set of control cards input after the ISOCLS card. If the user attempts to change this parameter, the input will be ignored.
END-OF-TAPE REACHED BEFORE END-OF-FIELD.	A field has been defined beyond the limits of the MSS DATAPE.
INPUT ERROR - A CLASSNAME CARD MUST BE INPUT BEFORE A GROUP OF FIELDS.	See section 9.5.4 on defining classes and fields.
NO. OF PIXELS TO BE UNPACKED PER SCAN EXCEEDS THE DIMENSION LIMIT OF ______.	Decrease the number of channels or pixels per scan in the field.
TOO MUCH DATA REQUESTED -- PIXELS *(CHANNELS + 1) CANNOT EXCEED ______.	Drum file will not hold all of the data for one class. Reduce channels or size of fields.
STORAGE REQUIRED FOR FIELD DEFINITION INFORMATION EXCEEDS THE DIMENSION LIMIT OF ______.	Reduce the number of fields. All vertices, names, and rectangular coordinates are saved for each field. The user has exceeded storage.
DIMENSION LIMITS EXCEEDED IN ISOCLS BY ______. REDUCE CHANNELS OR MAX. CLUSTERS.	The user has exceeded storage. The number of channels or maximum clusters per class should be reduced.
DIMENSION LIMIT OF ______ FOR COVARIANCES EXCEEDED.	Same.

Message	Explanation
WRITE ON UNIT _____ TERMINATED ABNORMALLY. DAS TAPE NOT CREATED. ISTAT = _____.	Printed by subroutine DSTAPE. User should resubmit the job with a different output tape. This diagnostic message indicates that either a bad type was being used or a tape drive error occurred.
END-OF-TAPE ON UNIT _____. LAST LINE WRITTEN.	Printed by DSTAPE. The end of reel has been encountered while attempting to write the MAPFIL tape.
INVALID INPUT CARD _____ IGNORED.	Printed by subroutine SETUP7. Check table 9-1 for correct spelling of keywords for card input and make sure the keyword is left justified in the field.

TABLE 9-1.— ISOCLS PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
CHANNELS	DATA=$C_1, C_2, C_3, \cdots, C_k$, STAT=$A_1, A_2, A_3, \cdots, A_k$ $k \leq$ number of channels on SAVTAP$\leq$30 Default: None	C's are integer channel numbers that (1) will be used in clustering and (2) refer to the MSS data tape (DATAPE). A's are integer channel numbers that (1) will be the starting vectors (initial means), (2) refer to the SAVTAP file, and (3) must be a subset of the channels on the SAVTAP file. The same channels must be used throughout one execution of ISOCLS. If a cluster MEANS deck is input, the channels on this card must be a subset of the channels in the MEANS deck.
OPTION	ORDER Default: The color keys will be ordered according to cluster numbers.	The color keys on the MAPFIL tape will be ordered according to greenness. See section 5.1 for further details of color keys.
OPTION	PUNCH=N Default: If PUNCH is omitted, no cards are punched; if N is omitted, it defaults to 1.	Punches the means and covariance matrix for each cluster in the module STAT deck format defined in section 3.1.4.1. N=1 punches module STAT deck; N=2 punches

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 9-1.— Continued.

Keyword	Parameter and default values	Function
		ERIPS interface deck; and N=3 punches both decks.
OPTION	STATS	Prints the covariance matrix for each cluster.
SEQUEN	AA···A Default: SC	A represents the sequence of S and C characters used for iteration control after the initial split sequence. A maximum of 19 characters may be input.
OPTION	ERCOMP	Prints an error criterion for each iteration.
SYMBOLS	$S_1, S_2, S_3, \cdots$ Default: 1,2,···9, A,B,···Z,%,#,Δ/,-,*,+, $,@,=,0,?, , ,),(,:,!, ,;, ,',comma,period, blank,	Symbols used to identify clusters in the printout.
FORMAT	UNIVERSAL Default: Output MAPFIL tape is not generated.	Generates the output cluster MAPFIL tape in Universal format (see section 5.1 for further information).
FORMAT	LARSYS Default: Output MAPFIL tape is not generated.	Generates the output cluster MAPFIL tape in LARSYS format.
OPTION	CLUSTER Default: If the FORMAT control card	The output cluster MAPFIL tape will contain the cluster number to which the corresponding

TABLE 9-1.– Continued.

Keyword	Parameter and default values	Function
	is input, the output cluster MAPFIL tape will contain the mean vector of the cluster to which the corresponding pixel was assigned.	pixel was assigned. When selecting this option, the FORMAT control card must be input also.
NMIN	N	Deletes any cluster with fewer than N members on the first through next-to-last iteration (see section 9.1.1).
DLMIN	X Default: 3.2	On a combine iteration, combines any two clusters whose means are closer than X units.
PMIN	N	Deletes any cluster with fewer than N members on last iteration (see section 9.1.1).
SEP	X Default: Maximum of the channel standard deviations in the cluster	When splitting a cluster, separates the new clusters by a distance of X units.
DATAFILE	UNIT=N,FILE=M Default: N=3,M=1	N is the Fortran logical unit number to which the MSS data tape (DATAPE) has been assigned; M is the file number on the tape to be processed. For back-to-back executions, if

TABLE 9-1.– Continued.

Keyword	Parameter and default values	Function
		the same data file is to be processed throughout the execution, only one DATAFILE card need be submitted.
STATFILE	INPUT/UNIT=N,FILE=M, OUTPUT/UNIT=L,FILE=S Default: No defaults for INPUT; L=1,S=1 for OUTPUT	N is the Fortran logical unit number to which the SAVTAP file containing the initial means has been assigned; M is the file number of the tape to be processed; L is the Fortran logical unit number to which the SAVTAP file containing the generated statistics will be output; S is the file number on the tape for saving the clustered statistics. (Input of initial means from SAVTAP file is illustrated in section 16, figure 16-4.)
ISTOP	N Default: 10	A maximum of N iterations is performed in the initial split sequence.
PERCENT	N Default: 80	N, an integer number, is the test variable for the percentage of stabilized clusters with standard deviations less than the threshold parameter STDMAX in the initial split iteration sequence.

TABLE 9-1.– Continued.

Keyword	Parameter and default values	Function
STDMAX	X Default: 4.5	On a split iteration, splits any cluster whose maximum standard deviation is greater than X units.
CLASSES	N Default: 1	Number of classes to be clustered (see section 9.5.4 for defining classes).
CLUSTERS	N Default: 60	Maximum number of clusters per class; N must be ≤ 60.
KRN	N Default: 20	Prints out a summary of the clusters at every N*th* iteration.
MAP	N Default: 20	Prints out a map of the clustered data along with the summary for every N*th* iteration. A final cluster map is printed regardless of this parameter.
CHAIN	X Default: Chaining not performed	Chains all clusters within X units of each other to form one cluster. Chaining of clusters affects only the final map printout and MAPFIL tape.
SUBCLASS	$C_1, C_2, C_3, \cdots, C_k$ $k \leq 60$ Default: All subclasses/clusters on SAVTAP file will be used in initializing the clustering.	C's are integer subclass or cluster numbers that (1) will be used in the initial means, (2) refer to the SAVTAP file, and (3) must be a subset of the subclasses or clusters on the SAVTAP file.

TABLE 9-1.— Continued.

Keyword	Parameter and default values	Function
MODULE	Blanks	Initializes the reading of the module STAT deck that immediately follows this card.
MEANS	CARDS Default: Clustering procedure is automatically initialized if this deck or MEANS file is not input.	Initializes input of the cluster MEANS deck defined in section 3.1.4.3. This deck is used to initialize cluster centers for the clustering procedure.
MEANS	FILE Default: Cluster centers are automatically initialized if this card or the MEAN card deck is not input.	Indicates means for initial clusters have been input previously from cards and stored on file. The same initial means are to be used again for initializing the process for a new data set.
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.

TABLE 9-1.– Concluded.

Keyword	Parameter and default values	Function
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Indicates the end of control cards.
$END*	Blank	Indicates the end of all classes to be clustered for this set of control cards. The SETUP routine will be reentered to read new control cards for the next class until all classes have been clustered.

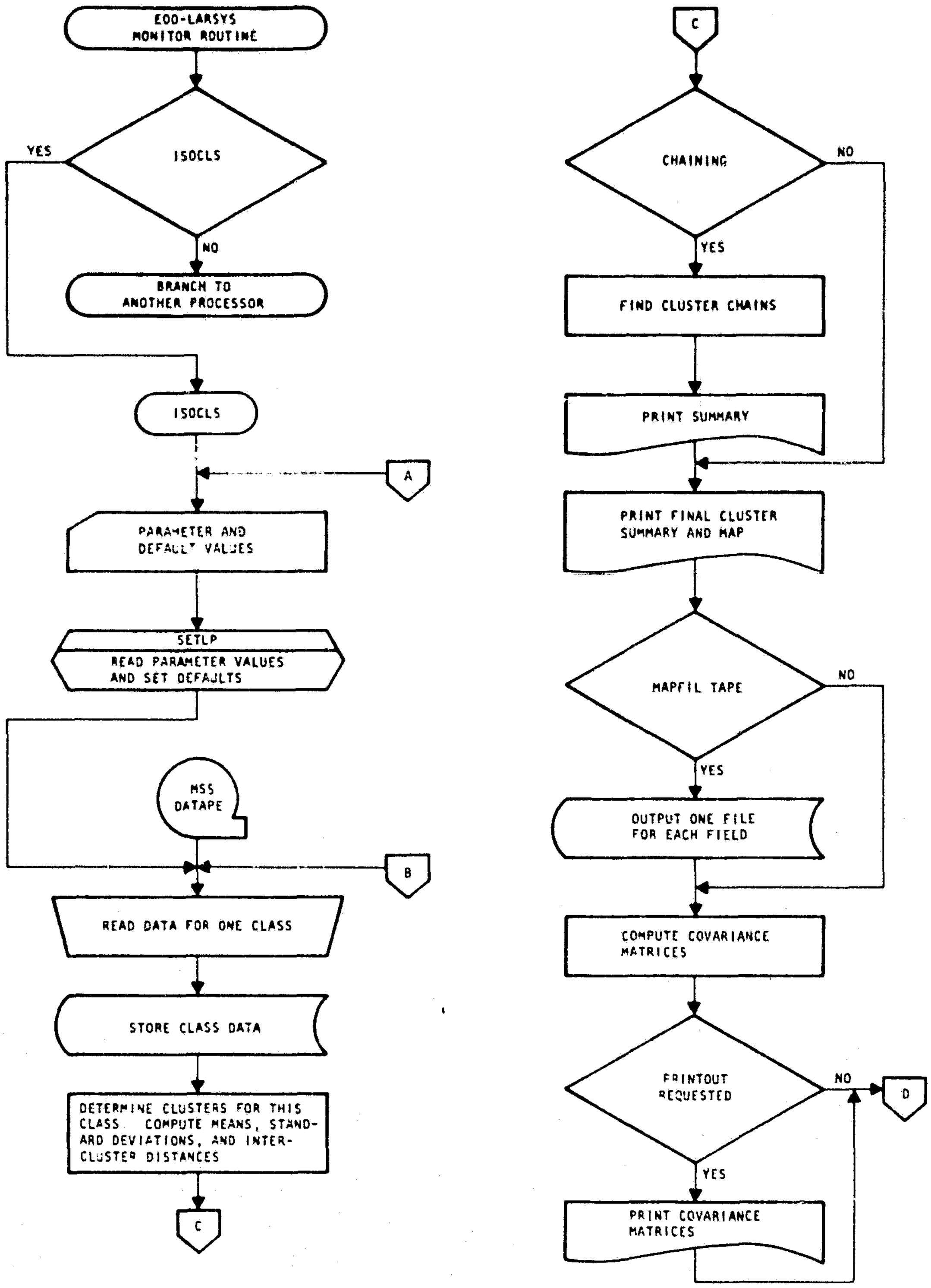


Figure 9-1.— Functional flow chart for the ISOCLS processor.

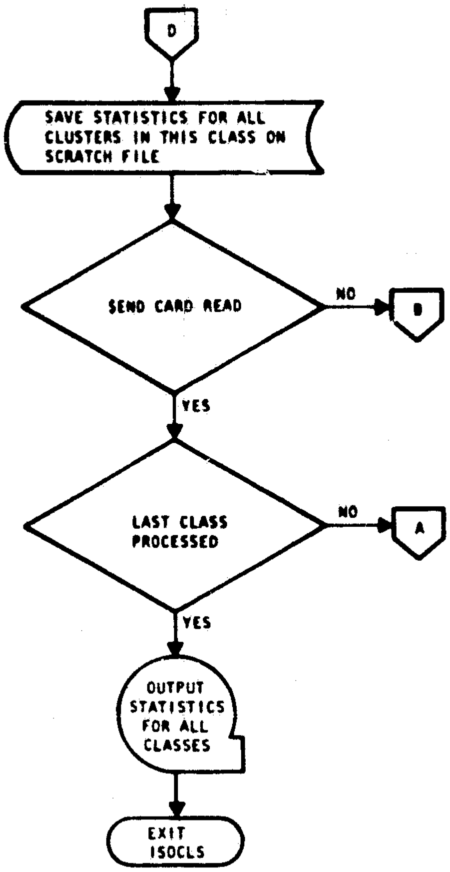
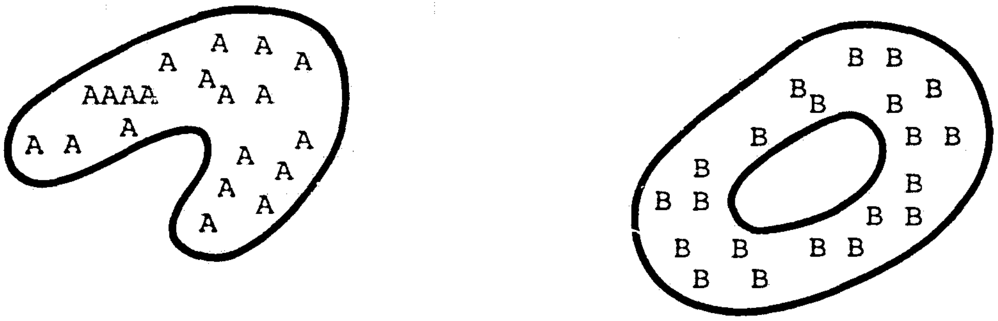


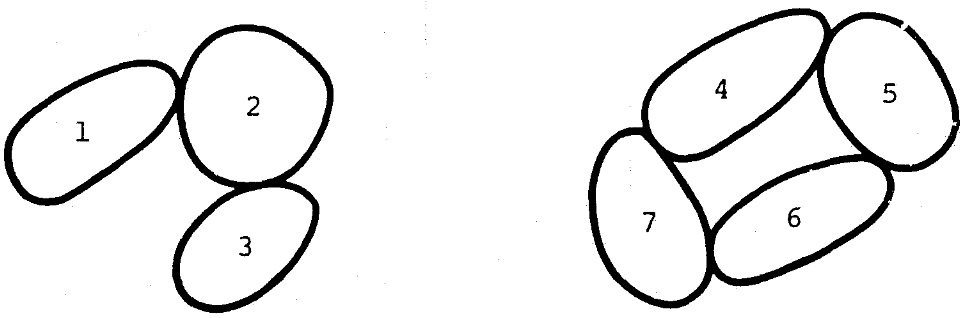
Figure 9-1.– Concluded.



(a) The boomerang-shaped cluster.

(b) The donut-shaped cluster.

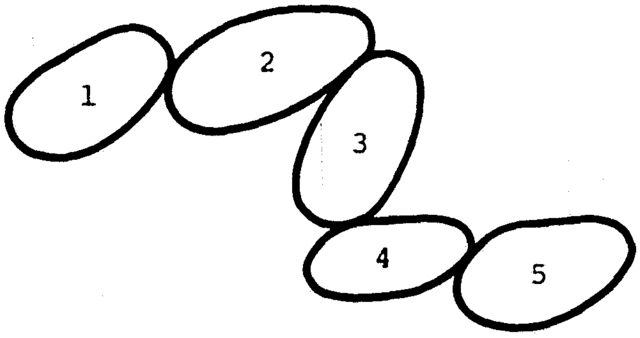
Figure 9-2.— Odd-shaped clusters.



(a) Subclustering of the boomerang-shaped cluster.

(b) Subclustering of the donut-shaped cluster.

Figure 9-3.— Breaking up of the clusters into subclusters.



(a) Cluster structure.

j \ i	1	2	3	4	5
1	0.0	7.5	6.2	3.2	11.8
2	7.5	0.0	3.1	5.6	3.0
3	6.2	3.1	0.0	3.1	6.3
4	3.2	5.6	3.1	0.0	9.7
5	11.8	3.0	6.3	9.7	0.0

CHNTHS = 3.2

(b) Intercluster distance table.

Figure 9-4.– Example of chaining.

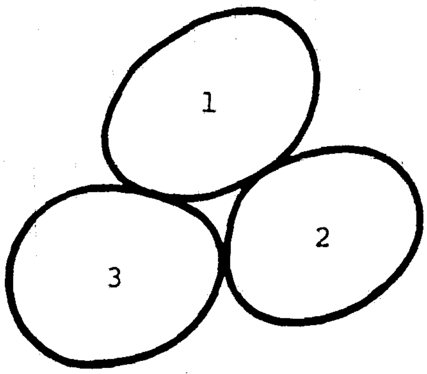
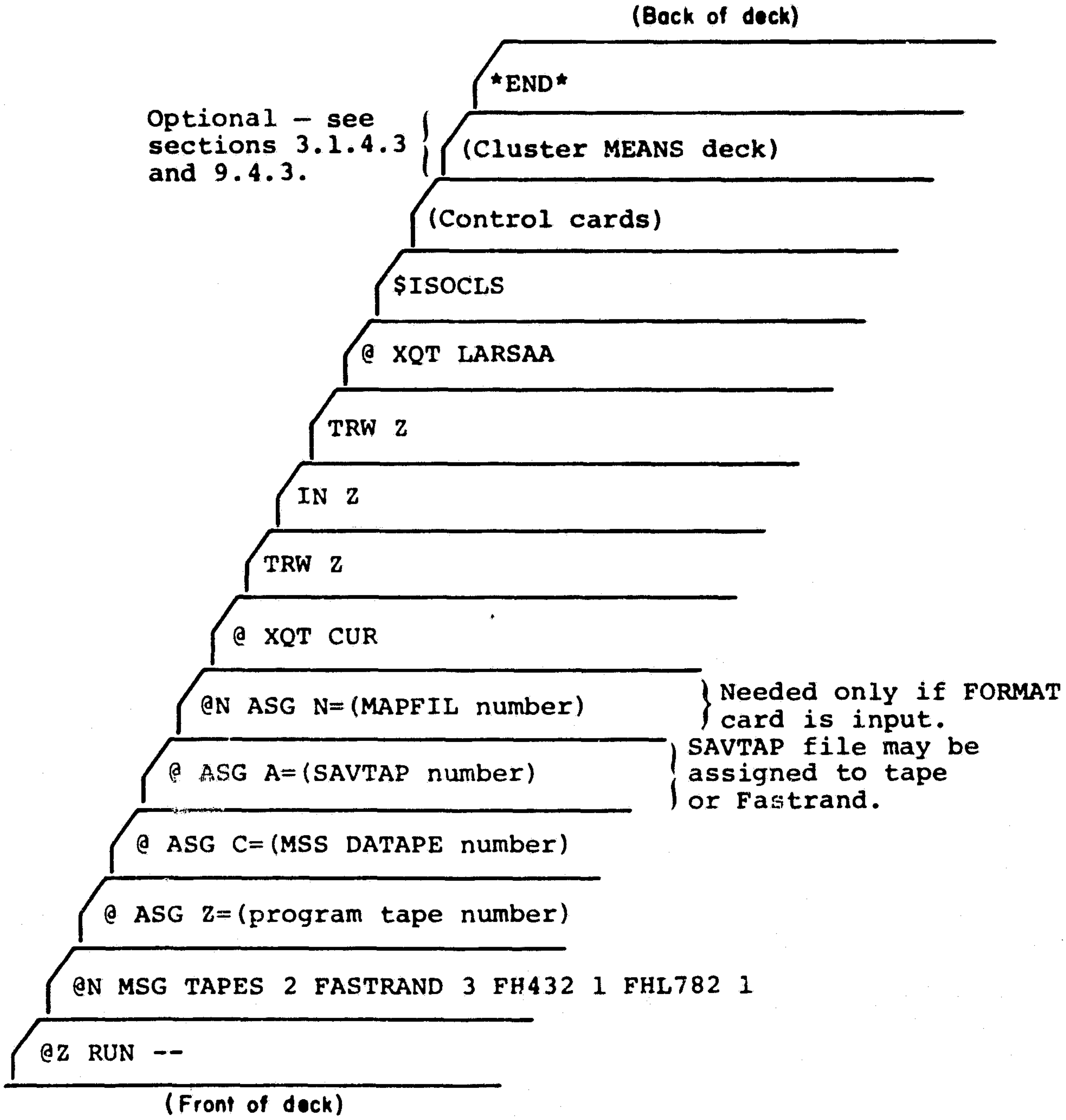


Figure 9-5.— Example in which chained subclusters can be combined safely into one composite cluster.



(a) For independent execution.

Figure 9-6.– Deck setup for the ISOCLS processor.

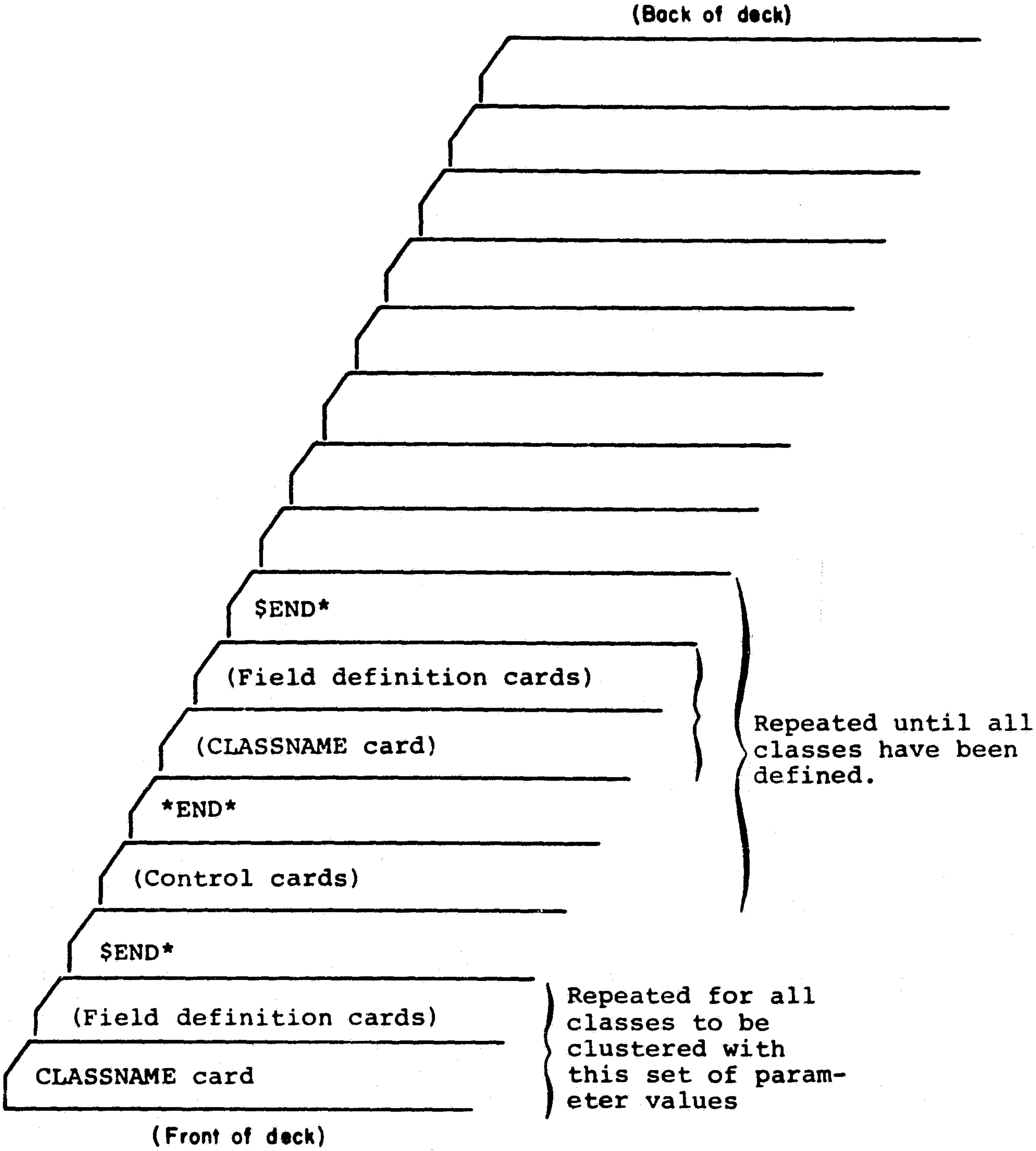
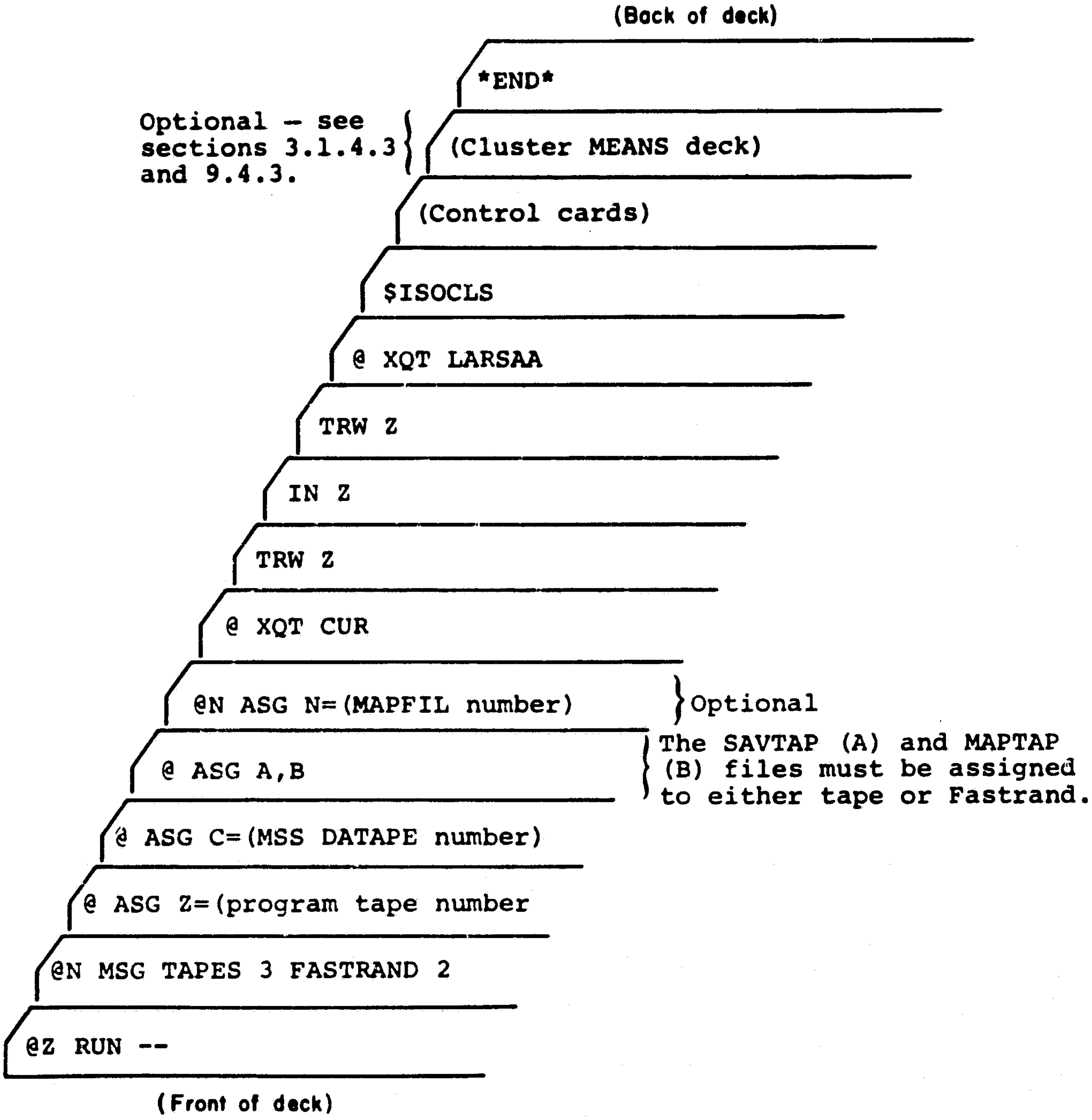


Figure 9-6.— Continued.



(b) For execution back to back with CLASSIFY and DISPLAY.

Figure 9-6.– Continued.

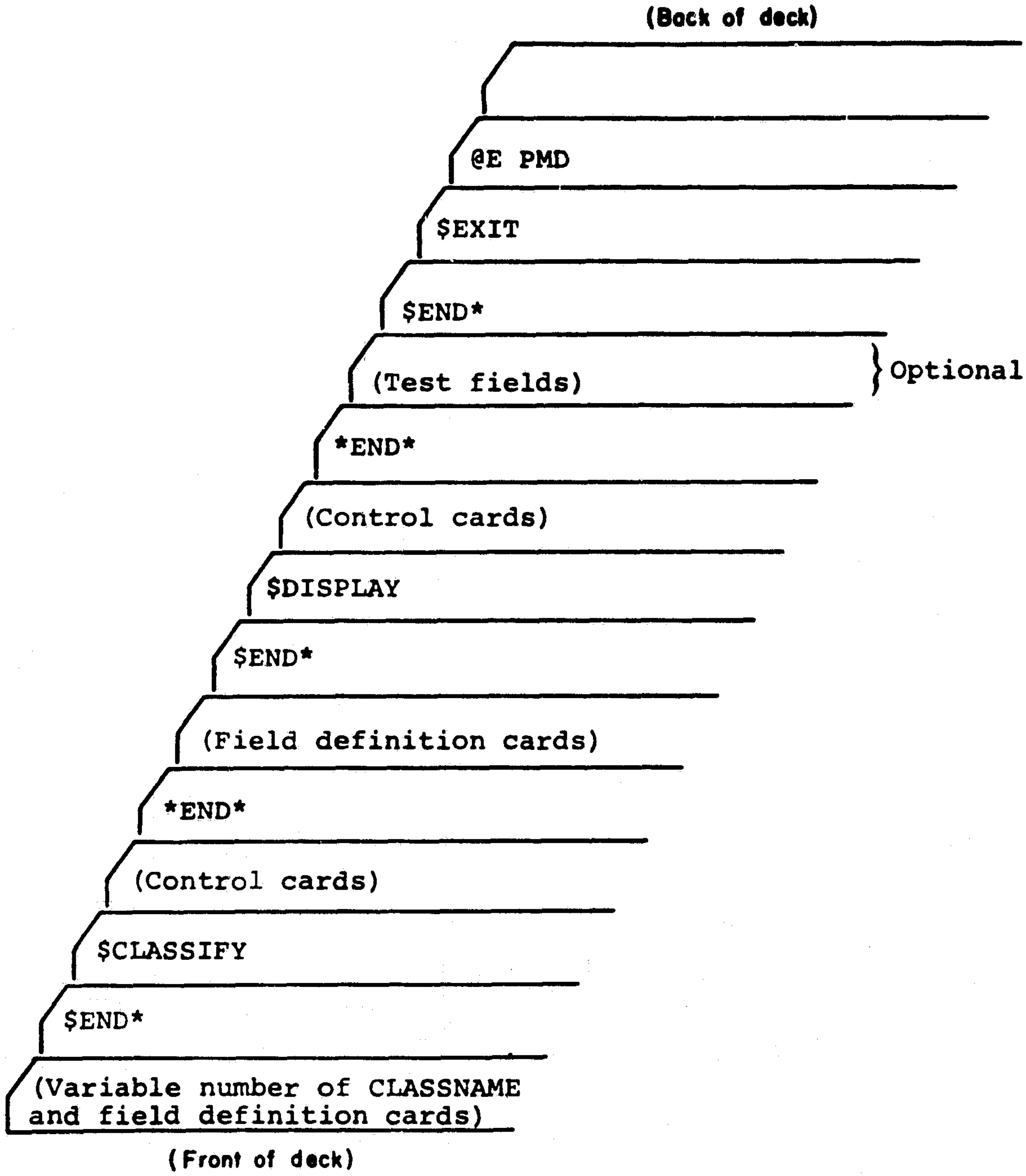


Figure 9-6.– Concluded.

C-3

```
@Z RUN L73179,TF7,H4,1659,Q619,C,20,5                               MINTER
@ ASG A
@ ASG C=V03662
@ ASG Z=V01366
@ XQT CUR
 TRW Z
IN Z
  TRW Z
@ XCT LARSAA
$ISOCLS
CHANNELS    DATA=1,2,3,4,5,6
*END*
CLASSNAME    ALL
LINEC1      (2,2),(1,1),(220,1),(220,950),(1,950)
$END*
$EXIT
@E PMD
```

Figure 9-7.– Sample program listing for the ISOCLS processor using all defaults except CHANNELS.

Card	Sample program listing	Comment/command
1	@7 RUN L73179,TF7,H4,1659,C619,C,10,5 MINTER	EXEC 2 run card
2	@ ASG A=SAVE1	Assign a file for the SAVTAP
3	@N ASG N=SAVE2	Assign a file for the MAPFIL
4		
5	@ ASG Z=V14837	Assign EOD-LARSYS program tape
6	@ ASG C=V02119	Assign MSS DATAPE
7	@ XQT CUR	Execute Univac complex utility routines
8	IN Z	Read program tape into system
9	TRW Z	Rewind program tape
10	@ XQT LARSAA	Execute EOD-LARSYS
11	$ISOCLS	Execute ISOCLS processor
12	CHANNELS DATA=1,2,3,4,5,6,7,8,9,10,11,12,13,14	Use these channels from the MSS image data tape
13	CLASSES 2	Two classes are to be clustered
14	CLUSTERS 20	Each class may have a maximum of 20 clusters
15	OPTIONS STATS,DAS,PUNCH	Print and punch statistics; write MAPFIL
16	KKN 2	Print a cluster summary every second iteration
17	ISTOP 8	Stop after eight iterations
18	STDMAX 3.5	Cluster splitting threshold is 3.5
19	DLMIN 2.0	Cluster combining threshold is 2.0
20	SYMBOLS /,*,M,X,=, ,W,O,Z,L	Use these 10 symbols for the first 10 clusters, use defaults for others.
21	NMIN 20	Each cluster must have at least 20 pixels
22	CHAIN 4.0	Perform chaining using 4.0 for the threshold
23	HED1 SAMPLE COMPUTER RUN FOR ISOCLS	Set the heading for printout
24	HED2 ALL OPTIONS USED	
25	COMMENT TRAINING FIELS FOR 2 CLASSES 'WHEAT' AND 'NON-WH'	
26	DATE MORTON COUNTY	
27	*END*	End of this set of control cards
28	CLASSNAME WHEAT	Field following this card will be clustered for class WHEAT
29	W9 (1,1),(363,175),(373,173),(376,180),(366,182)	Training field for class WHEAT
30	W25 (1,1),(366,185),(377,183),(380,190),(370,192)	
31	W44 (1,1),(364,193),(394,192),(397,198),(387,200)	
32	W49 (1,1),(343,199),(367,196),(370,202),(347,206)	
33	W52 (1,1),(303,206),(313,204),(316,210),(306,212)	
34	W94 (1,1),(323,223),(333,222),(340,238),(330,240)	
35	W185 (1,1),(366,262),(376,261),(378,264),(368,266)	
36	W41 (1,1),(411,189),(421,187),(424,194),(414,196)	
37	W187 (1,1),(324,266),(335,264),(338,271),(330,272),(329,269)*	
38	(326,269)	Continuation of field W187
39	W56 (1,1),(428,197),(438,195),(441,202),(431,204)	Training field for class WHEAT
40	W147 (1,1),(456,235),(466,233),(469,240),(459,241)	
41	W150 (1,1),(402,243),(412,242),(415,248),(405,250)	
42	W167 (1,1),(446,247),(455,245),(459,252),(450,253)	
43	W196 (1,1),(426,267),(435,265),(436,266),(427,268)	
44	W69 (1,1),(366,222),(376,220),(377,222),(367,224)	
45	$END*	End of all classes for this set of control cards
46	CLUSTERS 30	Change maximum clusters per class to 30
47	*END*	End of control cards for next set of classes

Figure 9-8.– Sample program listing for the ISOCLS processor using two sets of control cards.

Card	Sample program listing		Comment/command
48	CLASSNAME NON-WHEAT		Fields following this card will be clustered for class NONWH*
49	F75	(1,1),(293,217),(303,216),(306,222),(296,224)	
50	F114	(1,1),(340,231),(350,229),(354,236),(343,238)	
51	F161	(1,1),(321,255),(331,254),(334,260),(323,262)	
52	F137	(1,1),(358,241),(368,239),(369,241),(360,243)	
53	F85	(1,1),(392,217),(402,215),(405,223),(395,225)	
54	F126	(1,1),(412,231),(422,230),(429,246),(419,247)	
55	F175	(1,1),(392,255),(406,253),(408,255),(393,257)	Training field for class NONWH
56	G59	(1,1),(417,204),(427,203),(428,205),(426,207),(418,209)	
57	G51	(1,1),(317,204),(338,203),(341,206),(319,210)	
58	S97	(1,1),(311,226),(317,225),(321,226),(322,227),(312,228)	
59	C151	(1,1),(388,245),(398,243),(400,246),(390,248)	
60	C174	(1,1),(410,252),(416,251),(419,258),(413,259)	
61	S188	(1,1),(463,255),(473,253),(476,259),(466,261)	
62	S18991	(1,1),(450,257),(459,255),(462,262),(456,261),(453,263)	
63	$END*		End of all classes for this set of control cards†
64	$EXIT		Exit EOD-LARSYS
65	@b PMC		Give a core dump if run errs

*Note that only the first six characters beginning with column 11 will be maintained for the class name.

†The SAVTAP file will be written at this point, since two classes have been clustered.

Figure 9-8.– Concluded.

Card	Sample program listing		Comment/command
1	Z RUN L78362,TF,LVIII,1659,C387,C,5,10		WILLS EXEC 2 run card
2	ASG A		Assign SAVTAP to Fastrand
3	ASG N		Assign MAPFIL to Fastrand
4	ASG Z=X09972		Assign EOD-LARSYS program tape
5	ASG C=X19977		Assign MSS DATAPE
6	XQT CUR		Execute Univac complex utility routine
7	TRW Z		Rewind program tape
8	IN Z		Read program tape into system
9	TRW Z		Rewind program tape
10	XQT LARSAA		Execute EOD-LARSYS
11	$ISOCLS		Execute ISOCLS processor
12	CHANNEL	DATA=1,2,3,4	Channels to be used for MSS DATAPE
13	CLASSES	1	Cluster 1 class
14	STATFILE	OUTPUT/UNIT=1,FILE=1	Output statistics on unit A, file 1
15	CLUSTER	20	Maximum of 20 clusters may be formed for this run
16	OPTION	STATS	Print means and covariances
17	OPTION	CLUSTER	Output on MAPFIL the cluster number to which each corresponding pixel was assigned
18	OPTION	PUNCH	Punch the module STAT deck
19	FORMAT	UNIVERSAL	Output MAPFIL tape in Universal format
20	KRN	2	Print a cluster summary every second iteration
21	ISTOP	8	Stop initial splitting after 8 iterations
22	PERCEN	90	Or stop initial splitting when 90% of the clusters have standard deviations less than STDMAX
23	SEQUEN	SCS	After the initial splitting, do a split, combine, and split iteration, then stop
24	STDMAX	3.6	Cluster splitting threshold is 3.6
25	DLMIN	2.0	Cluster combining threshold is 2.0
26	SYMBOLS	/,*,M,=, ,N	Use these 5 symbols for the first 5 clusters, then use default for others
27	NMIN	30	All except last iteration will contain clusters with at least 30 points
28	PMIN	26	The last iteration will contain clusters with at least (26 + number of channels) points
29	CHAIN	4.0	Perform chaining using 4.0 for the threshold
30	HED1	SAMPLE COMPUTER RUN FOR ISOCLS	
31	HED2	MOST OPTIONS USED	Set heading for printout
32	COMMENT	CLUSTERING A LACIE SEGMENT	
33	DATE	MAY 1977	
34	*END*		End of this set of control cards
35	CLASSNAME	ALL	CLASSNAME card
36	FIELD	(1,1),(1,1),(196,1),(196,117),(1,117)	Field definition of segment to cluster
37	$END*		End of card input to ISOCLS
38	$EXIT		Exit EOD-LARSYS
39	E PMD		Give a core dump if run errs

Figure 9-9.— Sample program listing and output for the ISOCLS processor using most options.

```
                                                     LYNDON B. JOHNSON SPACE CENTER              06 MAY 77
                                                           HOUSTON,TEXAS

$ISOCLS

INPUT SUMMARY

     CHANNE     DATA=1,2,3,4
     CLASSE     1
     STATFI     OUTPUT/UNIT=1,FILE=1
     CLUSTE     20
     OPTION     STATS
     OPTION     CLUSTER
     OPTION     PUNCH
     FORMAT     UNIVERSAL
     KRN        2
     ISTOP      8
     PERCEN     90
     SEQUEN     SCS
     STDMAX     3.6
     DLMIN      2.0
     SYMBOL     /,*,M,=, ,N
     NMIN       30
     PMIN       26
     CHAIN      4.0
     HED1                SAMPLE COMPUTER RUN FOR ISOCLS
     HED2                           MOST OPTIONS USED
     COMMEN     CLUSTERING A LACIE SEGMENT
     DATE       MAY 1977
     *END*

YOU HAVE SELECTED THE FOLLOWING PARAMETER VALUES AND   OPTIONS

STOP AFTER     8 ITERATION(S)
ALLOW A MINIMUM OF     30 PIXELS PER CLUSTER
PRINT A CLUSTER SUMMARY EVERY     2 ITERATION(S)
PRINT A CLUSTER MAP EVERY   20 ITERATION(S)
ALLOW A MAXIMUM OF   20 CLUSTERS PER CLASS
THE STATISTICS FILE WILL BE WRITTEN AFTER    1 CLASS(ES) HAVE BEEN CLUSTERED
CHANNELS ARE---  1  2  3  4
DLMIN =  2.000
STDMAX=  3.600
CHAIN CLUSTERS WHICH ARE  4.000 UNITS APART
PUNCH THE MODULE STAT DECK
WRITE A CLUSTER MAP OUTPUT TAPE IN UNIVERSAL FORMAT

INPUT IMAGE DATA TAPE INFORMATION
```

Figure 9-9.– Continued.

```
FORMAT                    UNIVERSAL
NO. OF CHANNELS               20
NO. OF PIXELS/LINE           190
FIRST SCAN LINE NO.            1
FIRST PIXEL REFERENCE PT       1
```

Figure 9-9.– Continued.

SAMPLE COMPUTER RUN FOR ISOCLS
MOST OPTIONS USED

CLUSTERING A LACIE SEGMENT MAY 1977

FIELDS TO BE CLUSTERED FOR CLASS ALL

FIELD NAME	SAMPLE INC.	LINE INC.	VERTICES (SAMPLE,LINE)
1 FIELD	1	1	(1, 1) (496, 1) (196, 117) (1, 117)

CUMULATIVE TIME AFTER ASSIGNING DATA TO CLUSTERS FOR ITERATION 2 IS .911650

Figure 9-9.– Continued.

SAMPLE COMPUTER RUN FOR ISOCLS
MOST OPTIONS USED

CLUSTERING A LACIE SEGMENT

INTERMEDIATE PRINTOUT FOR ITERATION 2

TOTAL NUMBER OF CLUSTERS = 2

TOTAL NUMBER OF POINTS = 22932

CLUSTER	SYMBOL	POINTS IN CLUSTER
1	/	10267
2	*	12665

MEANS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	26.30	25.26	32.90	16.76
2	22.02	19.26	21.79	10.82

STANDARD DEVIATIONS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	4.32	7.01	4.87	2.57
2	2.11	3.30	3.30	2.35

DISTANCES BETWEEN CLUSTERS

CLUSTER	1	2
1	.00	4.06
2	4.06	.00

CLUSTER 1 IS SPLIT IN THE 2TH PARAMETER INTO CLUSTER 3
CUMULATIVE TIME AFTER ASSIGNING DATA TO CLUSTERS FOR ITERATION 4 IS .665167

Figure 9-9.– Continued.

```
                                   SAMPLE COMPUTED RUN FOR ISOCLS                                   MAY 1977
                                        MOST OPTIONS USED
        CLUSTERING A LACIE SEGMENT


INTERMEDIATE PRINTOUT FOR ITERATION     4


TOTAL NUMBER OF CLUSTERS =  4
TOTAL NUMBER OF POINTS =  22932

CLUSTER     SYMBOL     POINTS IN CLUSTER
   1          /             2411
   2          *            12299
   3          M             5599
   4          =             2623

              MEANS

CLUSTER        CH( 1)   CH( 2)   CH( 3)   CH( 4)
   1            31.99    34.32    39.29    19.30
   2            21.89    19.06    21.64    10.71
   3            23.07    19.98    30.00    16.36
   4            27.93    28.40    30.17    14.98


           STANDARD DEVIATIONS

CLUSTER        CH( 1)   CH( 2)   CH( 3)   CH( 4)
   1             2.77     4.46     3.44     1.75
   2             2.00     3.13     3.30     2.28
   3             2.03     3.42     3.20     2.32
   4             1.66     2.17     2.55     1.78

              DISTANCES BETWEEN CLUSTERS
CLUSTER         1          2          3          4
   1           .00       9.09       6.13       4.77
   2          9.00        .00       3.61       6.09
   3          6.13       3.61        .00       4.13
   4          4.77       6.09       4.13        .00
 CLUSTER  1 IS SPLIT IN THE  2TH PARAMETER INTO CLUSTER  5



CUMULATIVE TIME AFTER ASSIGNING DATA TO CLUSTERS FOR ITERATION   4 IS   .970517
```

Figure 9-9.– Continued.

CLUSTERING A LACIE SEGMENT

INTERMEDIATE PRINTOUT FOR ITERATION 8

TOTAL NUMBER OF CLUSTERS = 5

TOTAL NUMBER OF POINTS = 22932

CLUSTER	SYMBOL	POINTS IN CLUSTER
1	/	1029
2	•	10480
3	M	5480
4	*	4245
5		1698

MEANS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	34.47	38.29	42.19	20.43
2	21.67	18.74	23.45	10.28
3	22.22	18.63	24.23	16.13
4	26.63	26.37	29.01	19.41
5	30.33	31.58	36.36	18.15

STANDARD DEVIATIONS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	1.65	2.97	2.81	1.59
2	1.84	2.83	3.07	2.12
3	1.67	2.76	3.42	2.40
4	1.46	2.15	2.92	1.99
5	1.08	2.55	2.42	1.48

DISTANCES BETWEEN CLUSTERS

CLUSTER	1	2	3	4	5
1	.00	13.54	11.14	8.48	9.40
2	13.54	.00	3.66	5.48	9.94
3	11.14	3.66	.00	4.33	7.39
4	8.48	5.48	4.33	.00	4.78
5	9.40	9.94	7.39	4.78	.00

USER INPUT=SPLIT-COMBINE SEQUENCE OF ITERATIONS
CUMULATIVE TIME AFTER ASSIGNING DATA TO CLUSTERS FOR ITERATION 8 IS 1.287967

Figure 9-9.— Continued.

SAMPLE COMPUTER RUN FOR ISOCLS MAY 1977
MOST OPTIONS USED

CLUSTERING A LACIE SEGMENT

INTERMEDIATE PRINTOUT FOR ITERATION 6

TOTAL NUMBER OF CLUSTERS = 5

TOTAL NUMBER OF POINTS = 22932

CLUSTER	SYMBOL	POINTS IN CLUSTER
1	/	1043
2	•	9046
3	M	5546
4	•	5025
5		2272

MEANS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	39.41	38.17	42.24	20.48
2	21.52	18.60	20.36	9.90
3	21.76	17.87	28.81	15.98
4	25.83	25.10	27.79	13.80
5	29.82	30.91	35.38	17.60

STANDARD DEVIATIONS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	1.70	3.08	2.79	1.50
2	1.73	2.63	2.06	1.97
3	1.55	2.50	3.03	2.45
4	1.46	2.17	2.70	1.94
5	1.84	2.77	2.65	1.60

DISTANCES BETWEEN CLUSTERS

CLUSTER	1	2	3	4	5
1	.00	14.24	11.74	9.91	4.76
2	14.24	.00	3.83	5.07	9.56
3	11.74	3.83	.00	4.25	7.25
4	9.91	5.07	4.25	.00	4.93
5	4.76	9.56	7.25	4.93	.00

Figure 9-9.– Continued.

```
                         SAMPLE COMPUTER RUN FOR ISOCLS                              MAY 1977
                             MOST OPTIONS USED
          CLUSTERING A LACIE SEGMENT

THE FOLLOWING CLUSTERS SHOULD BE CHAINED---   2   3
IN THE FINAL OUTPUT MAP ALL OF THE ABOVE CLUSTERS WILL BE REPRESENTED BY THE SYMBOL FOR CLUSTER   2

THE ABOVE CHAINING REDUCES THE EFFECTIVE NUMBER OF CLUSTERS TO     4
```

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 9-9.– Continued.

SAMPLE COMPUTER RUN FOR ISOCLS
MOST OPTIONS USED

MAY 1977

CLUSTERING A LACIE SEGMENT

FINAL CLUSTER SUMMARY FOR CLASS ALL

TOTAL NUMBER OF CLUSTERS = 5

TOTAL NUMBER OF POINTS = 22932

CLUSTER	SYMBOL	POINTS IN CLUSTER
1	/	1043
2	*	9046
3	*	5546
4	*	5025
5		2272

MEANS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	34.41	38.17	42.24	20.48
2	21.52	18.60	20.36	9.93
3	21.76	17.87	28.81	15.98
4	25.83	25.10	27.79	13.80
5	29.82	30.91	35.38	17.68

STANDARD DEVIATIONS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	1.70	3.08	2.74	1.50
2	1.73	2.63	2.86	1.97
3	1.55	2.50	3.63	2.45
4	1.96	2.17	2.76	1.99
5	1.89	2.77	2.65	1.60

DISTANCES BETWEEN CLUSTERS

CLUSTER	1	2	3	4	5
1	.00	14.24	11.74	9.91	4.74
2	14.24	.00	3.83	5.07	9.56
3	11.74	3.83	.00	4.25	7.25
4	9.91	5.07	4.25	.00	4.93
5	4.76	9.56	7.25	4.93	.00

Figure 9-9.— Continued.

CLUSTERING A LACIE SEGMENT

FIELD

TOTAL NUMBER OF POINTS IN THIS FIELD 22932

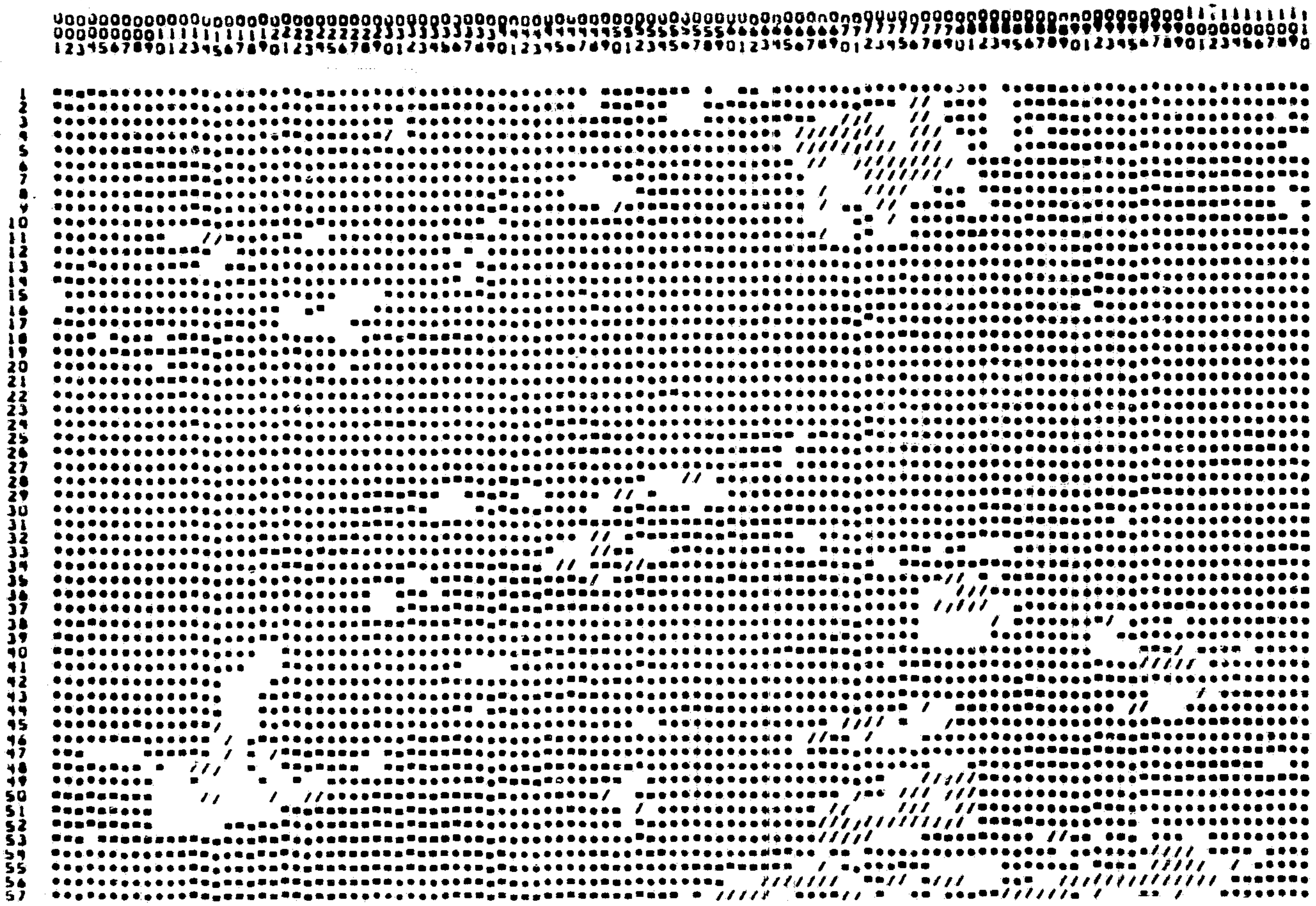


Figure 9-9.— Continued.

POINTS PER CLUSTER IN THIS FIELD

CLUSTER	SYMBOL	POINTS
1	/	1093
2	•	9096
3	•	5596
4	■	5025
5		2272

Figure 9-9.— Continued.

SAMPLE COMPUTER RUN FOR ISOCLS
MOST OPTIONS USED

MAY 1977

CLUSTERING A LACIE SEGMENT

```
FILE NO.      =       1
FIELD NAME    = FIELD
FORMAT        = UNIVERSAL
NO. OF SCAN LINES =    117
NO. OF COLOR KEY SCAN LINES =      0
```

Figure 9-9.— Continued.

SAMPLE COMPUTER RUN FOR ISOCLS
MOST OPTIONS USED

MAY 1977

CLUSTERING A LACIE SEGMENT

COVARIANCES FOR CLASS ALL

COVARIANCE MATRIX FOR CLUSTER 1

CH(1)	CH(2)	CH(3)	CH(4)
2.93			
3.64	9.96		
1.92	2.99	7.98	
.53	.65	3.09	2.46

COVARIANCE MATRIX FOR CLUSTER 2

CH(1)	CH(2)	CH(3)	CH(4)
2.99			
3.52	6.91		
1.79	2.92	8.20	
.52	.63	9.69	3.88

COVARIANCE MATRIX FOR CLUSTER 3

CH(1)	CH(2)	CH(3)	CH(4)
2.90			
2.79	6.24		
1.53	.93	13.15	
.29	-.86	7.69	5.99

Figure 9-9.– Continued.

COVARIANCE MATRIX FOR CLUSTER 4

CH(1)	CH(2)	CH(3)	CH(4)
2.13			
2.03	4.73		
1.47	1.63	7.60	
.54	.42	4.22	3.75

COVARIANCE MATRIX FOR CLUSTER 5

CH(1)	CH(2)	CH(3)	CH(4)
3.40			
3.80	7.68		
.87	.84	7.01	
-.15	-.55	3.11	2.56

Figure 9-9.— Continued.

```
                                   SAMPLE COMPUTER RUN FOR ISOCLS                                   MAY 1977
                                         MOST OPTIONS USED
        CLUSTERING A LACIE SEGMENT


THE STATISTICS FILE FOR    1 CLASSES AND    5 SUBCLASSES HAS BEEN WRITTEN
THE STATS WERE WRITTEN ON FILE    1
THE STATS FOR A PARTICULAR CLASS OR SUBCLASS SHOULD BE REFERRED TO IN LATER RUNS BY
THE FOLLOWING NAMES AND NUMBERS (WHICHEVER APPLICABLE)


    CLASS  1  ALL        SUBCLASSES (TOTAL=  5)

                            1  ALL001
                            2  ALL002
                            3  ALL003
                            4  ALL004
                            5  ALL005
TIME FOR ISOCLS     1.786
```

Figure 9-9.– Continued.

```
                    SAMPLE COMPUTER RUN FOR ISOCLS                    MAY 1977
                           MOST OPTIONS USED
          CLUSTERING A LACIE SEGMENT

      $EXIT





      @E PMD
      MOT ERROR MODE - NO DUMP                                        06 MAY 77
```

Figure 9-9.– Continued.

```
06 MAY 77   22:46:46   IDENT LVIII   ACCOUNT L78342   CARDS IN   40 CARDS OUT   28   PAGES   4,   ELAPSED TIME  0 2 55

*******************************EXEC-II-UNIVAC-1108-1-V13DA-JSC-NASA-HOUSTON-TX.*******************************
```

Figure 9-9.— Concluded.

10. FEATURE SELECTION PROCESSOR — SELECT

The feature selection processor SELECT provides a means of measuring the relative importance of the individual channels and obtaining the set of channels which provides the best discrimination between subclasses. The processor allows the user to choose one of the following three criteria for measuring the separability of the subclasses for a set of channels or for linear combinations of the channels.

- Weighted average interclass divergence
- Weighted average transformed divergence
- Weighted average Bhattacharyya distance

Either the Exhaustive Search or the Without Replacement Procedure can be used with one of the above criteria to select a "best" set of channels. The Exhaustive Search Procedure determines the best set of k out of n channels by computing the separability measure for every possible combination of k channels. This results in $n!/k!(n - k)!$ computations of the separability measure. The computer time required for this procedure is prohibitive for a large n. In such cases, the Without Replacement Procedure could be used.

The Without Replacement Procedure determines the best k out of n channels in the following manner. First, the single channel which extremizes the separability measure is selected. Each of the remaining $(n - 1)$ channels are paired with the best single channel in selecting the best pair of channels. The best triplet is determined by combining the remaining $(n - 2)$ channels with the best pair. The process continues until the best set of k channels has been selected. The number of times the separability measure must be computed is $n + (n - 1) + (n + 2) + \cdots (n - k + 1)$.

A third procedure, the Davidon-Fletcher-Powell Procedure, is a powerful iterative descent method for finding a local minimum of a function of several variables. The procedure is discussed in reference 6. How the procedure applies to the problem of channel selection or dimensionality reduction is discussed in reference 7. In SELECT, the Davidon-Fletcher-Powell Procedure computes a k-by-n linear transformation matrix which extremizes a given separability measure. This matrix, referred to as the B-matrix, is saved on the BMFILE (section 4.2) and optionally is punched on cards (B-Matrix Deck, section 3.1.4.2) for later input to the CLASSIFY, SELECT, TRSTAT, SCTRPL, or DATA-TR processors.

An initial guess for the B-matrix must be provided for the Davidon-Fletcher-Powell routines and may be input via the B-matrix deck or BMFILE. If the initial guess is not provided by the user, SELECT will execute the Without Replacement Procedure first to obtain a best set of channels, which it will use to initialize a first-guess B-matrix for the Davidon-Fletcher-Powell Procedure.

In addition to selecting a best set of channels and/or linear combinations, the processor will evaluate any one of the three separability measures for a specified linear combination of the channels. The linear combination must be input via the B-matrix deck or the BMFILE if SELECT has been executed previously in the same run. This option is the fourth procedure defined under the PROCEDURE control card.

The processor will also evaluate any of the separability measures for specified sets of channels. This request is made using the EVALUATE and PROCEDURE control cards. This is the fifth option defined under the PROCEDURE control card.

See the functional flow chart for the SELECT processor (fig. 10-1).

10.1 INPUT FILES

The SELECT processor requires the statistics output from either STAT or ISOCLS. Both STAT and ISOCLS write the SAVTAP file and optionally punch the module STAT deck (see section 3.1.4.1 for format) which may be used as input to SELECT.

10.2 OUTPUT FILES

The BMFILE is output by SELECT when the Davidon-Fletcher-Powell Procedure is used (see appendix H for sample execution). The file is written on logical unit H (Fortran unit 10) and must be assigned to tape or Fastrand.

The corresponding B-matrix deck is punched if the OPTION PUNCH control card is included in the deck setup.

10.3 SCRATCH FILES

The random access drum files are used as scratch files in SELECT. No assignment is necessary.

10.4 CARD INPUT

All system card input formats referred to in this section are defined in section 3.

10.4.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$SELECT

This card directs the monitor routine to execute SELECT and initiates loading of routines used by SELECT.

10.4.2 SYSTEM CARD DECKS

The processor will read and process the module STAT deck and the B-matrix deck.

10.4.3 CONTROL CARDS

Table 10-1 lists the control cards which are recognized by SELECT.

10.4.4 FIELD DEFINITIONS

Field definitions do not apply to the SELECT processor.

10.4.5 DECK SETUP

The deck setup for the SELECT processor is given in figure 10-2. The @ in column 1 indicates the master punch for the Univac system, which is the 7-8 multipunch.

10.5 CARD OUTPUT

SELECT outputs the B-matrix deck on option (see control card OPTION PUNCH). This is optional output only when the Davidon-Fletcher-Powell Procedure is executed.

10.6 SAMPLE COMPUTER RUNS

The two computer runs listed in figures 10-3 and 10-4 demonstrate the use of all defaults and the use of all options, respectively, for the SELECT processor.

Run 1 (fig. 10-3) demonstrates the use of all defaults. Output from this run is not shown.

Run 2 (fig. 10-4) demonstrates the use of all options with a specific criterion and procedure. Input of a B-matrix deck is not shown. Some of the output from this computer run is given.

10.7 RESTRICTIONS

The system-related restrictions in section 17 apply to the SELECT processor.

Two large arrays are dimensioned in SELECT and used for the variable dimensioning of several smaller arrays. Storage in one array is a function of the number of subclasses and channels requested. That is,

$$\left[\begin{matrix}\text{Number of}\\\text{channels}\end{matrix}\left(\frac{\begin{matrix}\text{Number of}\\\text{channels}\end{matrix}+3}{2}\right)\right]\begin{matrix}\text{Number of}\\\text{subclasses}\end{matrix}+\left[\begin{matrix}\text{Number}\\\text{of best}\end{matrix}\left(\begin{matrix}\text{Number}\\\text{of best}\end{matrix}+3\right)\right]\begin{matrix}\text{Number of}\\\text{subclasses}\end{matrix}$$

$$+\left(\begin{matrix}\text{Number of}\\\text{subclasses}\end{matrix}\right)\left(\begin{matrix}\text{Number of}\\\text{subclasses}\end{matrix}+3\right)\leq 10\ 600 \qquad (10\text{-}1)$$

Storage requirements in the other array are dependent on the procedure and criterion being used. The Davidon-Fletcher-Powell Procedure requires much more storage than the other procedures, and the weighted average interclass divergence requires more storage than the other criteria. Requirements for each are given below.

a. Exhaustive Search and Without Replacement Procedures

- Weighted average interclass divergence:

$$\left[\begin{matrix}\text{Number of}\\\text{channels}\end{matrix}\left(\begin{matrix}\text{Number of}\\\text{channels}\end{matrix}+1\right)\right]\left(\frac{\begin{matrix}\text{Number of}\\\text{subclasses}\end{matrix}+8}{2}\right)+\left[\begin{matrix}\text{Number}\\\text{of best}\end{matrix}\left(\begin{matrix}\text{Number}\\\text{of best}\end{matrix}+1\right)\right]$$

$$\times\ \begin{matrix}\text{Number of}\\\text{subclasses}\end{matrix}\leq 12\ 000 \qquad (10\text{-}2)$$

- Weighted average transformed divergence and Bhattacharyya distance:

$$2\left(\begin{matrix}\text{Number of}\\\text{channels}\end{matrix}\right)\left(\begin{matrix}\text{Number of}\\\text{channels}\end{matrix}+3\right)\leq 12\ 000 \qquad (10\text{-}3)$$

b. Davidon-Fletcher-Powell Procedure

- Weighted average interclass divergence:

$$\left[\begin{matrix}\text{Number of}\\ \text{channels}\end{matrix}\begin{pmatrix}\text{Number of}\\ \text{channels}\end{pmatrix} + 1\right]\left(\frac{\begin{matrix}\text{Number of}\\ \text{channels}\end{matrix}}{2} + 8\right) + \left[\begin{matrix}\text{Number}\\ \text{of best}\end{matrix}\begin{pmatrix}\text{Number}\\ \text{of best}\end{pmatrix} + 1\right]$$

$$\times \begin{matrix}\text{Number of}\\ \text{subclasses}\end{matrix} + 12\begin{pmatrix}\text{Number of}\\ \text{channels}\end{pmatrix}\begin{pmatrix}\text{Number}\\ \text{of best}\end{pmatrix} \leq 12\ 000 \tag{10-4}$$

- Weighted average transformed divergence and Bhattacharyya distance:

$$\text{Approximately } 14\begin{pmatrix}\text{Number of}\\ \text{channels}\end{pmatrix}\begin{pmatrix}\text{Number}\\ \text{of best}\end{pmatrix} \leq 8000 \tag{10-5}$$

10.8 DIAGNOSTIC MESSAGES

Message	Explanation
CORE OVERFLOW IN SUBRAY - NN - STORAGE LOCATIONS NEEDED FOR THIS PROBLEM.	User might reduce the number of subclasses or channels or try another procedure. The SUBRAY array is used for temporary storage in SELECT only. (See restrictions, section 10.7)
CORE OVERFLOW IN ARRAY - NN*2 - STORAGE LOCATIONS NEEDED FOR THIS PROBLEM.	See suggestions for first diagnostic message. The ARRAY array is used throughout the system for variably dimensioned storage.
TOO MANY EVALUATE REQUESTS -- REMAINDER IGNORED.	The buffer to hold EVALUATE requests is dimensioned 100. The number of channels and channels to be evaluated for each EVALUATE request are stored in this array.

Message	Explanation
GROUP CARD IN ERROR - IGNORED.	Check format of GROUP option.
PROGRAM CANNOT PROCESS LESS THAN 2 CHANNELS.	At least two channels must be input.
PROGRAM CANNOT PROCESS LESS THAN 2 CLASSES.	At least two classes must be input.
INVALID CONTROL CARD - IGNORED.	Check spelling of keyword.
REDUCED COVARIANCE MATRIX FOR CLASS N IS NOT POSITIVE DEFINITE.	The indicated covariance matrix cannot be inverted.
THE INCLUDE REQUEST FOR CHANNEL N IS NOT A LEGITIMATE REQUEST - IGNORED.	The indicated channel to be included is not among the input channels.

TABLE 10-1.– SELECT PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
BEST	$N_1, N_2, \cdots$ Default: None	Finds the best set of N_1, $N_2, \cdots$ channels if procedure 1 or 2 is indicated. If procedure 3 is indicated, the best N_1, N_2 linear combinations of the channels are found. $N_1, N_2, \cdots$ are integers separated by commas. A request can be made for a maximum of 10 best in one call to SELECT.
SUBCLASSES	$C_1, C_2, \cdots, C_k$ $k \leq$ number of subclasses on SAVTAP≤ 60 Default: All subclasses on the SAVTAP file	Provides for use of only subclasses $C_1, C_2, \cdots$ statistics for computation of separability measure; allows the user to select a subset of the statistics on the SAVTAP file for use in computing the subclass separabilities. $C_1, C_2, \cdots$ are integers representing the subclass number as it occurs in the SAVTAP file.
CHANNELS	$C_1, C_2, \cdots, C_k$ $k \leq$ number of channels on SAVTAP≤ 30	Selects the best set of channels from those indicated on this card. Must be a subset

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 10-1.– Continued.

Keyword	Parameter and default values	Function
	Default: All channels on the SAVTAPE file	of the channels for which statistics are input via the SAVTAP file or module STAT deck. $C_1, C_2, \cdots$ are integers separated by commas.
OPTION	STATS Default: No statistics printed	Prints a summary of the statistics for the subclasses and channels actually used in SELECT.
WEIGHTS	C1=XX,(C1,C2)=YY, OTHERS=ZZ Default: All weights set to 1.0 for criteria 2 and 3. For criterion 1, weights for subclass pair (i,j) are $W_{ij}=e^{-D_{ij}/16}$, where D_{ij} is the divergence for subclass pair (i,j).	Sets weights for all subclass pairs of subclasses C1 to XX, then sets subclass pair (C1, C2) to YY; sets all other subclass pairs to ZZ. Subclass names C1,C2, etc., must match a subclass name from the module STAT deck, the SAVTAP file, or a GROUP name.[c]

[c]Consider the problem of selecting channels which best separate wheat from nonwheat classes, where wheat is divided into subclasses W1, W2, and W3, and nonwheat is divided into the subclasses NW1, NW2, NW3, and NW4. It is desirable to set all weights between subclasses in each class to zero, whereas wheat/nonwheat class pair weights are set to 1. This can be accomplished by the following WEIGHTS control cards: W1=1.,W2=1.,W3=1.,(W1,W2)=0.; and (W1,W3)=0.,(W2,W3)=0.,OTHERS=0. W1=1. will set weights for the following subclass pairs equal to 1: (W1,NW1),(W1,NW2),(W1,NW3),(W1,NW4),(W1,W2),(W1,W3). W2=1. will set the weights for the following subclass pairs equal to 1: (W2,NW1),(W2,NW2),(W2,NW3),(W2,NW4),(W2,W3),(W2,W1). W3=1. will set weights for the following subclass pairs equal to 1: (W3,NW1),(W3,NW2),(W3,NW3),(W3,NW4),(W3,W1),(W3,W2). (W1,W2)=0. resets this subclass pair weight to 0. OTHERS=0. sets all other subclass pair weights to 0.

TABLE 10-1.– Continued.

Keyword	Parameter and default values	Function
B-MATRIX	CARDS Default: None	Indicates that the B-matrix card deck immediately follows; results in the evaluation of the separability measure using the linear combinations defined by the B-matrix if procedure 4 is indicated. If procedure 3 is indicated, the B-matrix will be used as a first guess for the Davidon-Fletcher-Powell Procedure.
B-MATRIX	FILE Default: None	Indicates that a previous execution of SELECT has written the BMFILE. Depending on the PROCEDURE card, the B-matrix on file will be used as an initial guess for the Davidon-Fletcher-Powell Procedure or in evaluating the separability measure.
EVALUATE	$C_1, C_2, \cdots$ Default: None	Evaluates the separability measure indicated on the CRITERION card for channels $C_1, C_2, \cdots$. The set of channels to be evaluated must be (1) a subset of the channels on CHANNEL card and (2) must be on one card. Several sets of channels may

TABLE 10-1.— Continued.

Keyword	Parameter and default values	Function
		be input by using more than one EVALUATE card.
MODULE	Blank	Indicates that the module STAT deck immediately follows. The SAVTAP file will be written as this card deck is read.
GROUP	NAME,I,J,··· Default: No grouping; individual subclasses are used.	Groups the training subclasses I,J,···, pools their statistics, and assigns NAME as the group name. NAME may be any six characters. Integers I,J,··· must correspond to the subclasses as they occur in the module STAT deck or the SAVTAP file.
PROCEDURE	N Default: N=2	N=1: The Exhaustive Search Procedure is used; N=2: The Without Replacement Procedure is used; N=3: The Davidon-Fletcher-Powell Procedure is used; N=4; The user-input B-matrix is used to evaluate the separability measure; and N=5: The Evaluate Channels Procedure is used.

TABLE 10-1.— Continued.

Keyword	Parameter and default values	Function
CRITERION	N Default: N=1	The indicated criterion is used to measure the separability between subclasses. N=1 for weighted average divergence; N=2 for weighted transformed divergence; and N=3 for weighted average Bhattacharyya distance.
INCLUDE	$C_1, C_2, \cdots$ Default: None	Includes channels $C_1, C_2, \cdots$ in the best set; meaningful only for the Without Replacement Procedure. $C_1, C_2, \cdots$ must be a subset of channels on CHANNELS card.
STATFILE	UNIT=N,FILE=M	N is the Fortran logical unit number to which the SAVTAP file has been assigned; M is (1) the file number from which the training statistics are to be retrieved and (2), if the module STAT deck is input, the file number on which the statistics are to be stored. If M≠1, this control card must precede the module STAT deck in the control card deck setup.

TABLE 10-1.– Concluded.

Keyword	Parameter and default values	Function
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
ICOUNT	N Default: N=300	Number of iterations for the Davidon-Fletcher-Powell Procedure.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comment printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

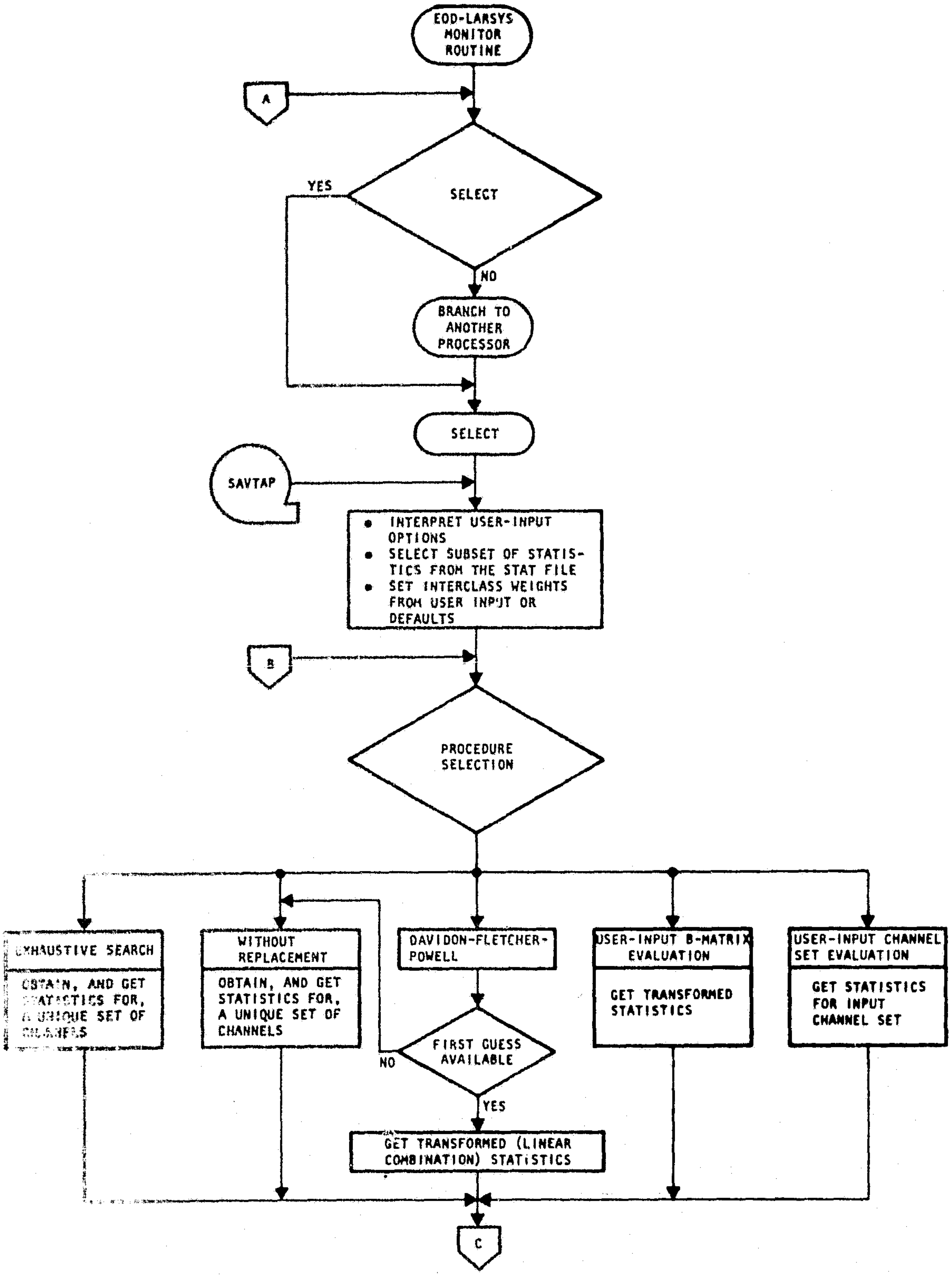


Figure 10-1.— Functional flow chart for the SELECT processor.

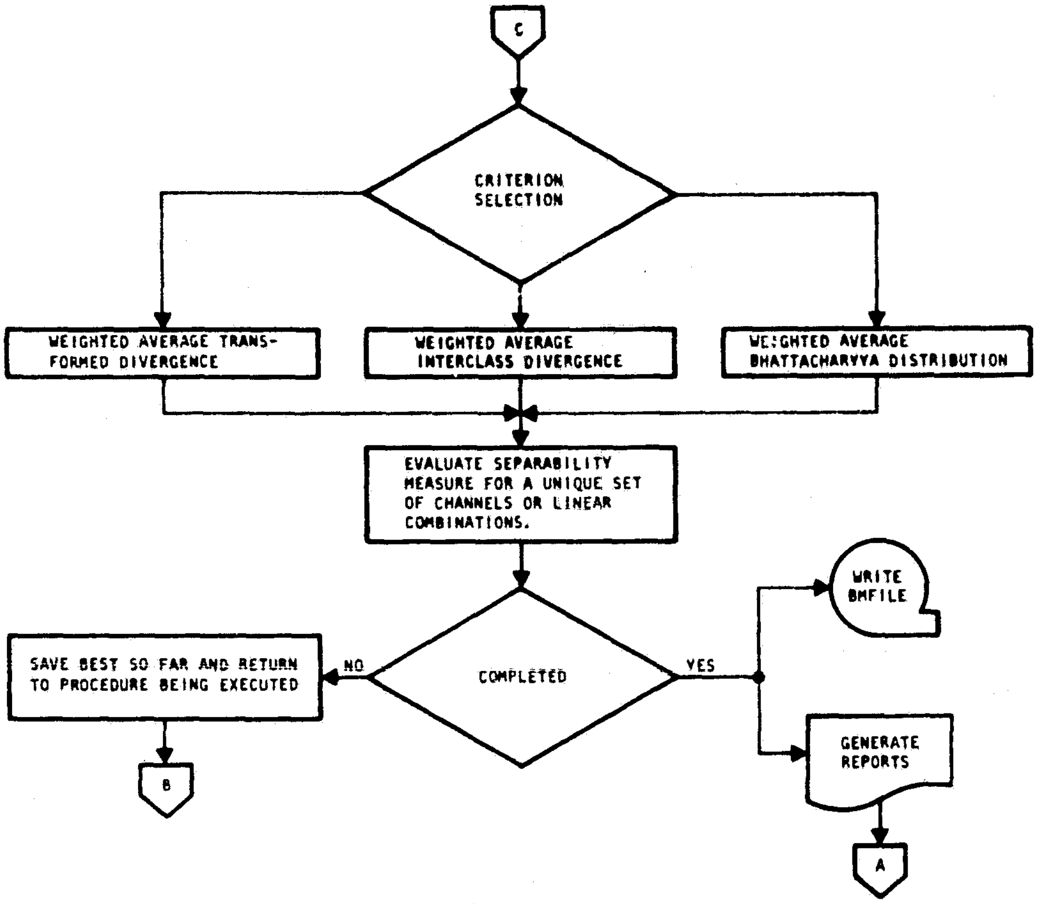


Figure 10-1.- Concluded.

(Back of deck)

@E PMD

$EXIT

$END*

END

Not necessary if SAVTAP is input { (Module STAT deck)

(Control cards)

$SELECT

@ XQT LARSAA

TRW Z

IN Z

TRW Z

@ XQT CUR

@ ASG Z=(program tape number)

@ ASG H=(BMFILE number) } Must be assigned if the Davidon-Fletcher-Powell Procedure is used.

@ ASG A=(SAVTAP file number) } Must be assigned to Fastrand or tape.

@N MST TAPES 1 FASTRAND 1 FH432 4

@ RUN --

(Front of deck)

(a) For independent execution.

Figure 10-2.— Deck setup for the SELECT processor.

(Back of deck)

$END*

Repeated for each class and subclass { (Variable number of training field definition cards)

(SUBCLASS name card)

(CLASSNAME card)

END

(Control cards)

$STAT

@ XQT LARSAA

TRW Z

IN Z

@ XQT CUR

@R ASG Z=(program tape number)

@R ASG C=(MSS DATAPE number)

@ ASG A,H } Assigns SAVTAP and BMFILE to Fastrand.

@ ASG B=(MAPTAP number) } Saves tape for classified data.

@ MSG TAPES 2 FASTRAND 2 FH432 1

@ RUN --

(Front of deck)

(b) For execution back to back with STAT and CLASSIFY.

Figure 10-2.— Continued.

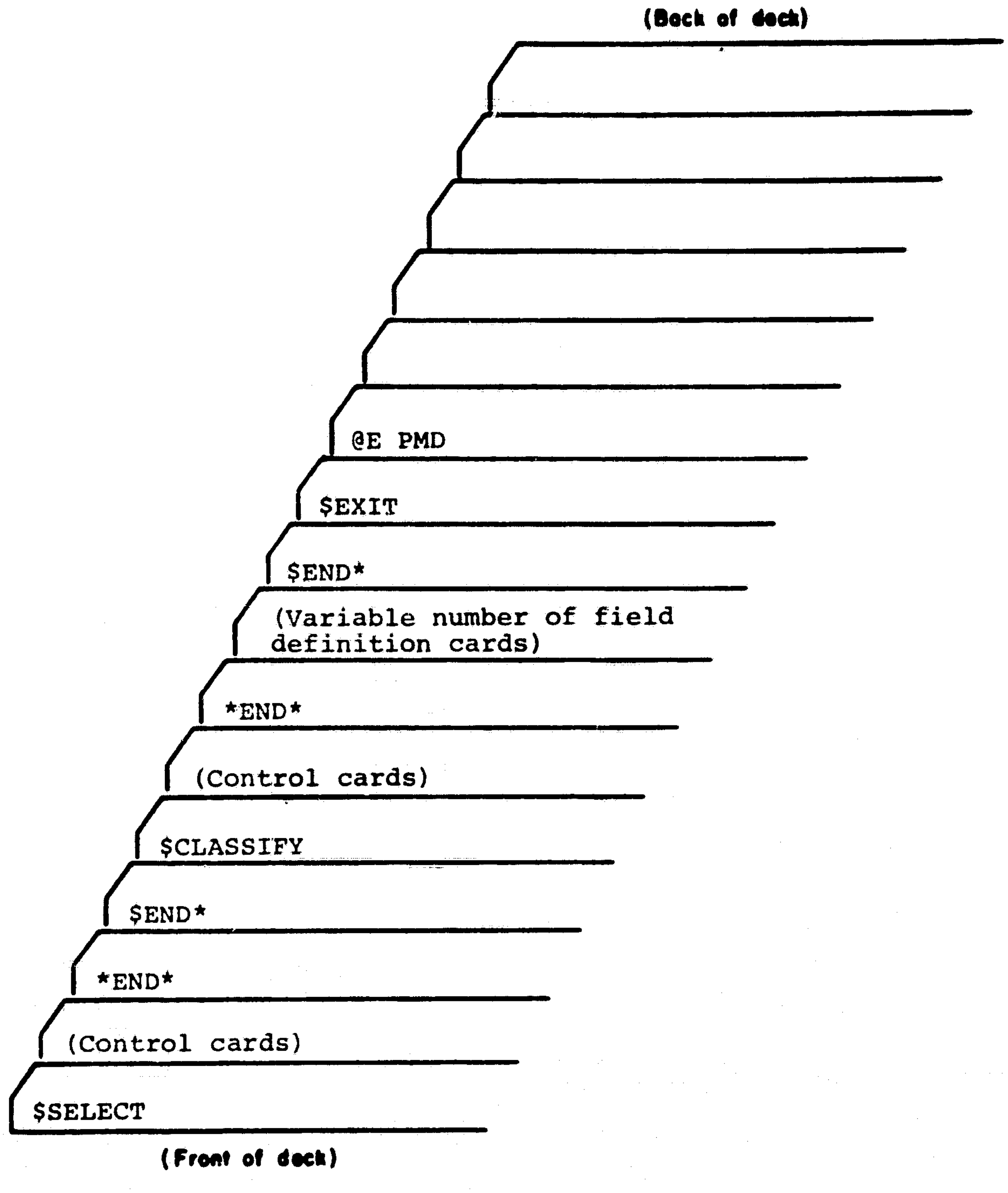


Figure 10-2.– Concluded.

Card	Sample program listing		Comment/command
1	@Z RUN L73179,TF7,H4,1659,0619,C,5,3	MINTER	EXEC 2 run card
2	@ ASG H		Assign [illegible]FILE to Fastrand
3	@ ASG A=V07090		Assign SAVTAP file
4	@ ASG Z=V14837		Assign EOD-LARSYS program tape
5	@ XCT CUR		Execute Univac tape complex utility routines
6	IN Z		Read program tape into system
7	TRW Z		Rewind program tape
8	@ XQT LARSAA		Execute EOD-LARSYS
9	$SELECT		Execute SELECT processor
10	BEST 4		Find the best set of four channels out of all channels on SAVTAP
11	*END*		End of control card input
12	$END*		End of all input for SELECT
13	$EXIT		Exit EOD-LARSYS
14	@E PMD		Give a core dump if the run errs

Figure 10-3.– Sample program listing for the SELECT processor using all defaults.

Card	Sample program listing	Comment/command
1	@Z RUN L73179,TF7,H4,1659,C619,C,10,5 MINTER	EXEC 2 run card
2	@ ASG H	Assign BMFILE to Fastrand
3	@ ASG A=V07090	Assign SAVTAP file
4	@ ASG Z=V14837	Assign EOD-LARSYS program tape
5	@ XQT CUR	Execute Univac complex utility routines
6	IN Z	Read program tape into system
7	TRW Z	Rewind program tape
8	@ XQT LARSAA	Execute EOD-LARSYS
9	$SELECT	Execute SELECT processor
10	BEST 4	Select best four channels (or a combination) from those on card 15.
11	PROCEDURE 3	Use Davidon-Fletcher-Powell Procedure
12	CRITERIA 2	Use average transformed divergence
13	SUBCLASSES 1,4,5,6,7,8,9,10,12,15,16,17,18,19,20,24,25	Retrieve statistics for these subclasses from SAVTAP
14	SUBCLASSES 26,27,28,29	Card 13 continued
15	CHANNELS 1,2,3,4,5,6,7,8,9,10,12,13,15,16	Retrieve statistics for these channels from SAVTAP
16	INCLUDE 4,9	Include channels 4 and 9 in best set for first-guess B-matrix
17	EVALUATE 1,5,9,13	Evaluate the transformed divergence for this set of channels
18	GROUP SWHT,4,7,9	Group subclasses 4, 7, and 9 into one subclass and call it SWHT
19	GROUP SWHT2,6,8,10	Group subclasses 6, 8, and 10 into one subclass and call it SWHT2
20	GROUP CT1,18,24,29	Group subclasses 18, 24, and 29 into one subclass and call it CT1
21	WEIGHTS SWHT=1.0,WHE001=1.0,WHE005=1.0,SWHT2=1.0	Set all wheat/nonwheat subclass weights to 1 and all others to 0.
22	WEIGHTS (SWHT,WHE001)=0.0,(SWHT,WHE005)=0.0,(SWHT,SWHT2)=0.0	
23	WEIGHTS (WHE001,WHE005)=0.0,(WHE001,SWHT2)=0.0,(WHE005,SWHT2)=0.0	
24	WEIGHTS OTHERS=0.0	
25	OPTIONS STATS,PUNCH	Print statistics and punch B-matrix deck
26	HED1 SAMPLE RUN FOR SELECT	Set the heading for printout
27	HED2 ALL OPTIONS USED	
28	COMMENT MORTON COUNTY CLUSTER STATS ON SAVTAP FILE	
29	DATE AUG. 25,1975	
30	*END*	End of control card input for SELECT
31	$END*	End of all input for SELECT
32	$EXIT	Exit EOD-LARSYS
33	@E PMD	Give a core dump if run errs

Figure 10-4.– Sample program listing and output for the SELECT processor using all options.

```
$SELECT

     BEST        4
     PROCED        3
     CRITER       2
     SUBCLA      1,4,5,6,7,8,9,10,12,15,16,17,18,19,20,24,25
     SUBCLA        26,27,28,29
     CHANNE      1,2,3,4,5,6,7,8,9,10,12,13,15,16
     INCLUD       4,9
     EVALUA       1,5,9,13
     GROUP       SWHT,4,7,9
     GROUP       SWHT2,6,8,10
     GROUP       OT1,18,24,29
     WEIGHT        SWHT=1.0,WHE001=1.0,WHE005=1.0,SWHT2=1.0
     WEIGHT        (SWHT,WHE001)=0.0,(SWHT,WHE005)=0.0,(SWHT,SWHT2)=0.0
     WEIGHT       (WHE001,WHE005)=0.0,(WHE001,SWHT2)=0.0,(WHE005,SWHT2)=0.0
     WEIGHT          OTHERS=0.0
     OPTION        STATS,PUNCH
     HED1                      SAMPLE RUN FOR SELECT
     HED2                         ALL OPTIONS USED
     COMMEN        MORTON COUNTY CLUSTER STATS ON SAVTAP FILE
     DATE        AUG. 25,1975
     .END.

YOU HAVE SELECTED THE FOLLOWING OPTIONS:
     PROCEDURE                      DAVIDON
     CRITERIA                       TRANS. DIV.
     SELECT THE BEST SET(S) OF       4,
     FROM CHANNELS                   1, 2, 3, 4, 5, 6, 7, 8, 9,10,12,13,15,16,
     INCLUDE IN THE BEST SET, CHANNELS 4, 9,
     USE INPUT WEIGHTS
```

Figure 10-4.– Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

HORTON COUNTY CLUSTER STATS ON SAVTAP FILE

SAVED TRAINING FIELDS

FIELD		CLASS		SUBCLASS	VERTICES (SAMPLE,LINE)				
1	A9	1	WHEAT		(363, 175)	(373, 173)	(376, 180)	(366, 182)	
2	A25	1	WHEAT		(366, 185)	(377, 183)	(380, 190)	(370, 192)	
3	A44	1	WHEAT		(384, 193)	(394, 192)	(397, 198)	(387, 200)	
4	A49	1	WHEAT		(343, 199)	(367, 196)	(370, 202)	(347, 206)	
5	A52	1	WHEAT		(303, 206)	(313, 209)	(316, 210)	(306, 212)	
6	A94	1	WHEAT		(323, 223)	(333, 222)	(349, 238)	(330, 240)	
7	A185	1	WHEAT		(366, 262)	(376, 261)	(378, 264)	(368, 266)	
8	A41	1	WHEAT		(411, 189)	(421, 187)	(424, 194)	(414, 196)	
9	A187	1	WHEAT		(324, 266)	(335, 264)	(338, 271)	(330, 272)	(329, 269)
					(326, 269)				
10	A56	1	WHEAT		(428, 197)	(438, 195)	(441, 202)	(431, 204)	
11	A147	1	WHEAT		(456, 235)	(466, 233)	(469, 240)	(459, 241)	
12	A150	1	WHEAT		(402, 243)	(412, 242)	(415, 248)	(405, 250)	
13	A167	1	WHEAT		(446, 247)	(455, 245)	(459, 252)	(450, 253)	
14	A196	1	WHEAT		(426, 267)	(435, 265)	(436, 266)	(427, 268)	
15	J89	1	WHEAT		(366, 222)	(376, 220)	(377, 222)	(367, 224)	
16	F75	2	NON-WH		(293, 217)	(303, 216)	(306, 222)	(296, 224)	
17	F118	2	NON-WH		(340, 231)	(352, 229)	(354, 236)	(343, 238)	
18	F161	2	NON-WH		(321, 255)	(331, 254)	(334, 260)	(323, 262)	
19	F137	2	NON-WH		(358, 241)	(368, 239)	(369, 241)	(360, 243)	
20	F85	2	NON-WH		(392, 217)	(402, 215)	(405, 223)	(395, 225)	
21	F126	2	NON-WH		(412, 231)	(422, 230)	(429, 246)	(419, 247)	
22	F175	2	NON-WH		(392, 255)	(406, 253)	(408, 255)	(393, 257)	
23	G59	2	NON-WH		(417, 204)	(427, 203)	(428, 205)	(426, 207)	(418, 209)
24	G51	2	NON-WH		(317, 204)	(338, 200)	(341, 206)	(319, 210)	
25	S97	2	NON-WH		(311, 226)	(317, 225)	(321, 226)	(322, 227)	(312, 228)
26	C151	2	NON-WH		(388, 245)	(398, 243)	(400, 246)	(390, 248)	
27	C174	2	NON-WH		(410, 252)	(416, 251)	(419, 258)	(413, 259)	
28	S188	2	NON-WH		(463, 255)	(473, 253)	(476, 259)	(466, 261)	
29	S18991	2	NON-WH		(450, 257)	(459, 255)	(462, 262)	(454, 261)	(453, 263)

Figure 10-4.– Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

SUBCLASS AHE001	CH(1)	CH(2)	CH(3)	CH(4)	CH(5)	CH(6)	CH(7)	CH(8)	CH(9)	CH(10)	CH(12)	CH(13)
MEAN	42.45	52.00	53.63	25.43	42.13	49.60	57.43	28.15	53.48	67.50	32.48	58.68

	CH(15)	CH(16)
MEAN	78.33	36.32

COVARIANCE MATRIX

3.48											
3.35	7.84										
2.40	5.10	5.20									
.91	1.65	1.36	1.05								
.34	.62	-.02	.34	3.82							
-1.30	.02	-.13	.26	5.81	14.61						
.64	1.59	1.56	.06	3.31	7.18	9.88					
-1.02	-2.27	.02	.35	-.60	1.43	4.32	16.09				
2.55	2.52	2.45	1.07	-.60	-3.07	-5.77	-6.24	14.72			
3.19	2.95	3.42	1.75	-1.41	-5.25	-8.73	-5.86	19.64	32.85		
.27	.78	1.33	.22	-.63	-1.51	-4.01	-2.84	6.96	10.76	5.85	
1.73	1.22	.54	.45	.84	-.07	1.11	.03	.59	1.61	-1.26	5.75
3.19	3.39	2.48	1.27	1.63	1.77	1.44	-1.18	4.93	7.25	1.41	4.54
1.29	.85	.83	1.05	.24	-.12	-.57	-.35	1.38	3.38	.23	1.79

13.16	
4.10	3.82

Figure 10-4.— Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

NORTON COUNTY CLUSTER STATS ON SAVTAP FILE

SUBCLASS SAMT

	CH(1)	CH(2)	CH(3)	CH(4)	CH(5)	CH(6)	CH(7)	CH(8)	CH(9)	CH(10)	CH(12)	CH(13)
MEAN	36.84	49.81	45.03	22.72	36.06	37.51	50.41	26.16	46.85	55.67	28.48	52.70
	CH(15)	CH(16)										
MEAN	68.11	31.95										

COVARIANCE MATRIX

6.22											
9.78	20.62										
4.02	7.49	45.80									
.49	.86	.84	1.64								
.22	1.08	-.28	.05	6.42							
-.62	.40	.14	.46	10.41	22.32						
2.50	5.09	1.12	.50	3.98	6.66	8.36					
3.11	5.54	1.76	.85	-2.57	-5.45	1.31	19.92				
3.74	6.65	6.38	.60	2.51	3.86	1.39	.21	12.77			
6.10	11.19	8.18	1.21	3.03	4.74	2.08	1.75	16.71	28.27		
1.90	4.23	3.52	.17	2.12	3.55	2.04	1.19	4.50	6.20	4.57	
3.64	7.31	6.06	.56	.24	-.14	.63	1.11	6.55	11.42	2.02	12.02
5.24	10.28	10.48	1.43	-1.60	-3.02	.20	3.95	7.83	15.46	3.13	15.39
2.62	4.72	3.00	.75	-2.00	-3.57	-.89	1.81	2.85	5.89	.82	6.75

31.81	
14.39	8.80

Figure 10-4.— Continued.

AUG. 25.1975

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

HURTON COUNTY CLUSTER STATS ON SAVTAP FILE

SUBCLASS	CH(1)	CH(2)	CH(3)	CH(4)	CH(5)	CH(6)	CH(7)	CH(8)	CH(9)	CH(10)	CH(12)	CH(13)
MEAN	28.77	39.23	30.48	14.37	36.75	38.11	49.17	29.46	40.09	42.96	28.59	48.36
	CH(15)	CH(16)										
MEAN	65.37	31.79										

COVARIANCE MATRIX

2.07											
1.68	4.00										
1.88	3.10	4.57									
.82	1.34	1.50	.77								
-.15	-.80	-1.18	-.16	6.67							
-.81	-1.17	-1.77	-.36	8.40	13.45						
.15	.31	.19	.11	2.68	3.35	3.68					
.39	1.16	.29	.33	-1.74	-2.63	-.81	9.18				
-.16	.98	.48	.13	-1.47	-2.92	-.67	1.73	5.30			
.35	3.17	1.09	.51	-3.79	-7.16	-1.08	4.48	8.68	29.36		
-.18	-.42	.22	.95	2.40	2.78	1.28	-2.17	-.37	-2.78	2.71	
.24	.31	-.08	-.08	-.53	-.84	.46	.28	-.35	.14	-.62	2.91
-.18	-1.12	-1.39	-.43	1.76	.43	1.10	1.60	-.37	.55	-.31	1.39
.09	-.57	-1.40	-.60	.91	.85	.81	.83	-.03	.15	-.98	1.38
5.99											
2.62	3.38										

Figure 10-4.– Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

HORTON COUNTY CLUSTER STATS ON SAVTAP FILE

SUBCLASS SWHT2

	CH(1)	CH(2)	CH(3)	CH(4)	CH(5)	CH(6)	CH(7)	CH(8)	CH(9)	CH(10)	CH(12)	CH(13)
MEAN	35.37	38.91	40.84	21.06	36.63	38.21	50.96	26.68	40.75	55.59	28.02	56.50

	CH(15)	CH(16)
MEAN	73.05	33.98

COVARIANCE MATRIX

10.95											
14.90	23.78										
15.68	24.52	114.29									
9.27	13.09	17.01	13.12								
1.54	2.52	3.34	2.48	9.91							
3.02	5.33	12.25	5.56	15.50	29.81						
2.73	4.25	1.81	2.79	4.26	10.64	9.38					
-1.05	-1.98	-6.14	-2.14	1.35	1.38	1.82	17.84				
6.85	10.35	22.42	8.29	12.28	19.21	7.36	-.63	26.04			
11.30	17.11	35.69	13.53	14.52	27.97	10.22	-1.41	36.02	55.36		
1.04	1.87	7.74	1.35	6.10	10.88	4.19	.58	12.45	17.16	9.29	
8.02	12.35	22.73	8.83	5.53	10.75	4.34	-1.96	14.09	22.12	4.93	15.42
7.07	11.31	27.69	7.77	5.16	10.34	3.62	-3.88	13.37	21.16	4.53	13.70
2.51	4.15	7.47	3.07	1.66	3.03	.99	-1.75	3.71	6.55	.98	4.39

20.51	
6.51	3.89

Figure 10-4.— Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

RESULTS FOR CHANNEL SELECTION ACTIVITY USING:
OPTIMIZATION PROCEDURE - WITHOUT REPLACEMENT
SEPARABILITY MEASURE - WEIGHTED AV. TRANSFORMED DIVERGENCE
CHANNELS CONSIDERED - 1, 2, 3, 4, 5, 6, 7, 8, 9,10,12,13,15,16.

CHANNELS SELECTED - 4, 9,16,13.
SEPARABILITY MEASURE FOR SELECTED CHANNELS - .56261566+00
MINIMUM SEP.MEASURE (USING ALL CHANNELS) - .44929611-01
RATIO - .79858494-01

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE SELECTED CHANNELS	ALL CHANNELS	RATIO
WHE001	SWHT	.000	.40367141+000	.26047739-001	.53054205-001
WHE001	WHE005	.000	.24890597-005	.19123013-008	.56854562-003
WHE001	SWHT2	.000	.27760314+000	.29095192-002	.10480858-001
WHE001	NON001	.100+01	.28884037-003	.12544487-013	.43431213-010
WHE001	NON004	.100+01	.67676399-003	.15856464-016	.23423695-013
WHE001	NON005	.100+01	.18562363-003	.56826558-018	.30613060-014
WHE001	NON006	.100+01	.11365363-005	.34741335-014	.30567731-008
WHE001	OT1	.100+01	.73039790-004	.36157564-009	.49503936-005
WHE001	NON008	.100+01	.20214737-001	.25695522-020	.12711282-018
WHE001	NON009	.100+01	.47767805-002	.55833993-011	.11688629-008
WHE001	NON014	.100+01	.52396961-005	.24260827-024	.48155338-019
WHE001	NON015	.100+01	.40080018-006	.15870423-016	.39588944-010
WHE001	NON016	.100+01	.55262152-002	.48786068-006	.88281160-004
WHE001	NON017	.100+01	.30181349-006	.87133469-019	.28869972-012
SWHT	WHE005	.000	.54097044-002	.71976017-004	.13317290-001
SWHT	SWHT2	.000	.60499953+000	.42629914+000	.70460546+000
SWHT	NON001	.100+01	.16500907-001	.17274263-012	.10468675-010
SWHT	NON004	.100+01	.29384883-001	.93341119-017	.45789381-010
SWHT	NON005	.100+01	.32130313-001	.55998417-008	.17198422-006
SWHT	NON006	.100+01	.32175182-003	.95256529-009	.29605592-005
SWHT	OT1	.100+01	.15986749-001	.83165802-006	.52021709-004
SWHT	NON008	.100+01	.12650798-001	.64630080-017	.51087749-015
SWHT	NON009	.100+01	.13985490+000	.25031255-005	.17898019-004
SWHT	NON014	.100+01	.94986610-002	.18351795-010	.19320402-008
SWHT	NON015	.100+01	.83431619-002	.87405086-007	.10480023-004
SWHT	NON016	.100+01	.63341418-001	.10474053-003	.16535867-002
SWHT	NON017	.100+01	.11729565-002	.15917071-008	.13570044-005
WHE005	SWHT2	.000	.18132076-001	.72747905-004	.40120947-002
WHE005	NON001	.100+01	.32477049-003	.15261623-015	.46992025-012
WHE005	NON004	.100+01	.86360799-004	.22274089-021	.25791898-017
WHE005	NON005	.100+01	.13618171+000	.93257992-006	.68480873-005

Figure 10-4.– Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25.1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE SELECTED CHANNELS	ALL CHANNELS	RATIO
WHE005	NON006	.100+01	.17520522-001	.23929316-003	.13657878-001
WHE005	OT1	.100+01	.23005174-001	.13806314-004	.60014083-003
WHE005	NON008	.100+01	.41226852-005	.12890564-024	.31267398-019
WHE005	NON009	.100+01	.14106626+000	.37214745-005	.26381052-004
WHE005	NON014	.100+01	.65513620-001	.29904134-006	.45645674-005
WHE005	NON015	.100+01	.12626223-001	.26217832-007	.20764588-005
WHE005	NON016	.100+01	.23985282-003	.28418363-010	.11848250-006
WHE005	NON017	.100+01	.40007696-001	.32061947-005	.80520797-004
SWHT2	NON001	.100+01	.69908458-002	.13452205-015	.19242600-013
SWHT2	NON004	.100+01	.45268218-003	.33678526-015	.74397729-012
SWHT2	NON005	.100+01	.42434661-001	.14146674-008	.33337591-007
SWHT2	NON006	.100+01	.93229551-003	.32519082-008	.34880659-005
SWHT2	OT1	.100+01	.18238348-001	.28493966-006	.15623107-004
SWHT2	NON008	.100+01	.13585422-002	.51487897-018	.37899372-015
SWHT2	NON009	.100+01	.97239859-001	.52919239-006	.54421344-005
SWHT2	NON014	.100+01	.52072390-002	.17855371-011	.34289517-009
SWHT2	NON015	.100+01	.60371918-003	.15114385-009	.25160483-006
SWHT2	NON016	.100+01	.23192449-001	.71834303-005	.30973143-003
SWHT2	NON017	.100+01	.11956744-002	.35968941-009	.29329842-006
NON001	NON004	.000	.49793279-001	.39291638-005	.78909520-004
NON001	NON005	.000	.30175376-001	.21665039-013	.71797081-012
NON001	NON006	.000	.54790374-004	.97590094-009	.17811590-004
NON001	OT1	.000	.30099240+000	.38964184-002	.12945239-001
NON001	NON008	.000	.36256751-003	.33523575-009	.92461606-006
NON001	NON009	.000	.51682991-001	.57424872-005	.11110981-003
NON001	NON014	.000	.24342558-003	.15913830-010	.65362193-007
NON001	NON015	.000	.20366622-001	.37923369-006	.18620353-004
NON001	NON016	.000	.17774463+000	.31794312-004	.17887635-003
NON001	NON017	.000	.77636740-002	.15629700-011	.20131835-009
NON004	NON005	.000	.62021924-003	.26740167-016	.43114048-013
NON004	NON006	.000	.95849926-004	.24603163-009	.25668421-005
NON004	OT1	.000	.12789121-001	.17761213-005	.13887752-003
NON004	NON008	.000	.43990702-001	.84907010-003	.19096993-001
NON004	NON009	.000	.11162228-001	.31044767-009	.27812339-007
NON004	NON014	.000	.36357063-002	.34386335-007	.94579519-005
NON004	NON015	.000	.15087332-002	.74030049-010	.49067688-007
NON004	NON016	.000	.18711161-002	.66969044-013	.35790961-010
NON004	NON017	.000	.40647799-003	.79428058-010	.17326414-006
NON005	NON006	.000	.35164910-003	.55569530-012	.15802552-008
NON005	OT1	.000	.68591789+000	.72632198-004	.10594769-003
NON005	NON008	.000	.19471366-005	.36938785-026	.18970829-020

Figure 10-4.— Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE SELECTED CHANNELS	ALL CHANNELS	RATIO
NON005	NON009	.000	.66099696+000	.25078676-001	.39150977-001
NON005	NON014	.000	.95620931-001	.88524071-003	.19409267-001
NON005	NON015	.000	.79664226+000	.22426493-001	.28151900-001
NON005	NON016	.000	.41965001-002	.99548295-011	.23721743-008
NON005	NON017	.000	.54303577+000	.62247261-001	.11495967+000
NON006	OT1	.000	.72866025-004	.28719102-005	.39413571-001
NON006	NON008	.000	.20965010-002	.65547562-006	.22620911-003
NON006	NON009	.000	.77143737-004	.81322857-008	.10541732-003
NON006	NON014	.000	.22948595-001	.62405850-005	.27193756-003
NON006	NON015	.000	.10065582-003	.17109369-007	.16997894-003
NON006	NON016	.000	.51409957-004	.24112098-009	.46906074-005
NON006	NON017	.000	.11786171-003	.90757402-008	.77003295-004
OT1	NON008	.000	.11463729-004	.77847388-009	.67907560-004
OT1	NON009	.000	.45986129+000	.99511736-002	.21677225-001
OT1	NON014	.000	.14450543-001	.15221753-004	.10533690-002
OT1	NON015	.000	.54496051+000	.48143369-001	.88423988-001
OT1	NON016	.000	.24376958-001	.70197853-005	.28796806-003
OT1	NON017	.000	.43994270+000	.42241467-003	.96125089-003
NON008	NON009	.000	.14021011-003	.11858473-012	.80011229-009
NON008	NON014	.000	.22041293-004	.16304126-016	.73970823-012
NON008	NON015	.000	.26636691-005	.12777307-013	.47968824-008
NON008	NON016	.000	.33826559-002	.19269331-013	.56965095-011
NON008	NON017	.000	.25229310-007	.12604150-018	.49958363-011
NON009	NON014	.000	.96506161-002	.33372309-004	.34580496-002
NON009	NON015	.000	.48963753+000	.26652531-001	.54433187-001
NON009	NON016	.000	.43409183-001	.42251083-003	.97332131-002
NON009	NON017	.000	.15101859+000	.33938917-002	.22473013-001
NON014	NON015	.000	.24319028-001	.81619029-005	.33560698-003
NON014	NON016	.000	.31168809-004	.36632326-008	.11752879-003
NON014	NON017	.000	.49479154-001	.59122076-002	.11948886+000
NON015	NON016	.000	.35532088-003	.76262735-008	.21463060-004
NON015	NON017	.000	.33032447+000	.69024094-002	.20895846-001
NON016	NON017	.000	.15232705-003	.10701447-008	.70256378-005

Figure 10-4.— Continued.

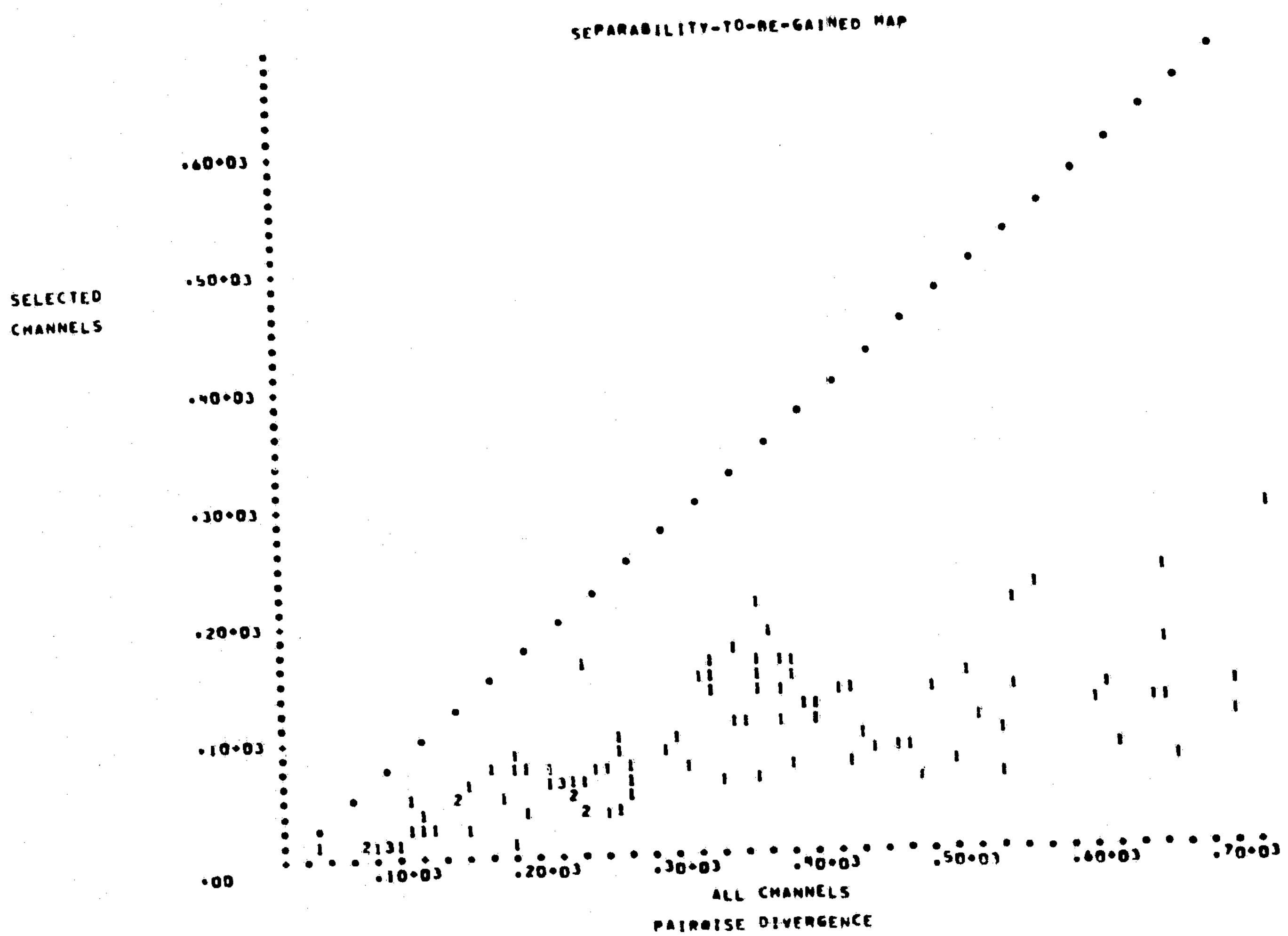


Figure 10-4.— Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

CONVERGENCE CHARACTERISTIC SUMMARY FOR THE DAVIDON-FLETCHER-POWELL PROCEDURE

NUMBER OF LINEAR COMBINATIONS = 4
DESIRED NO. OF FUNCTIONAL EVAL. = 300
MIN. WEIGHTED AV.TRANS. DIVERGENCE (T)= .99930-01

CONVERGENCE CHARACTERISTIC SUMMARY

CYCLE	FUNCTIONAL EVALUATIONS	FUNCTIONAL VALUE T B	RATIO T/ T R
1	1	.5626157+00	.7985899-01
2	38	.4173919+00	.1076937+00
3	43	.4117191+00	.1091268+00
MAX. ITERATIONS PER CYCLE - BEGIN NEW CYCLE			
4	75	.6768978+00	.6630068-01
5	98	.4139316+00	.1086798+00
6	126	.4139298+00	.1086753+00
MAX. ITERATIONS PER CYCLE - BEGIN NEW CYCLE			
7	158	.4139298+00	.1086753+00

Figure 10-4.– Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

LINEAR TRANSFORMATION (B) MATRIX

NO. LINEAR COMB. = 4
NO. CHANNELS = 14

LIN. CMB.	CH(1)	CH(2)	CH(3)	CH(4)	CH(5)	CH(6)	CH(7)	CH(8)	CH(9)	CH(10)	CH(12)	CH(13)
1	.8144+00	.1046+01	.1002+01	.1005+01	-.7331+00	-.1266+01	-.2571+00	-.1081+01	-.3042-01	.1606+00	.1239-01	.2645-01
2	-.3220+00	-.7272+00	-.1787+00	.6017-01	.6162+00	.9454+00	-.6098-01	-.6151-01	.1023+01	.5021+00	-.1341+00	.1924-01
3	.4787+00	.4262+00	.2022+00	-.8545-02	.4627+00	.5167+00	.4933+00	-.8377-01	-.4087-02	-.1502+00	.5940-02	.1003+01
4	.1628+01	.2720+01	.9047+00	-.1154-01	-.2872+01	-.4164+01	-.3699+00	.1852+01	-.3689-01	-.8068+00	.1781+01	-.2224-02

LIN. CMB.	CH(15)	CH(16)
1	-.2360-01	-.2085-01
2	-.3204+00	-.7437-01
3	.1307+00	.1613-02
4	.2583+01	.1008+01

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Figure 10-4.— Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

NORTON COUNTY CLUSTER STATS ON SAMTAP FILE

RESULTS FOR CHANNEL SELECTION ACTIVITY USING:
OPTIMIZATION PROCEDURE - DAVIDON-FLETCHER-POWELL
SEPARABILITY MEASURE - WEIGHTED AV. TRANSFORMED DIVERGENCE
CHANNELS CONSIDERED - 1, 2, 3, 4, 5, 6, 7, 8, 9,10,12,13,15,16,

NO. OF LINEAR COMBINATIONS - 4
SEPARABILITY MEASURE FOR LINEAR COMB. - .91392981+00
MINIMUM SEP.MEASURE (USING ALL CHANNELS) - .44929611-01
RATIO - .10867531+00

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE LINEAR COMBINATION	ALL CHANNELS	RATIO
WME001	SWMT	.000	.24292987+000	.26097739-001	.10722329+000
WME001	WME005	.000	.14619571-004	.19123013-008	.96603969-004
WME001	SWMT2	.000	.30639107+009	.29095192-002	.94960966-002
WME001	NON001	.100+01	.86380183-007	.12594687-013	.14521300-006
WME001	NON004	.100+01	.92375868-011	.15856964-016	.37419797-005
WME001	NON005	.100+01	.53290775-006	.56826558-018	.10673503-011
WME001	NON006	.100+01	.21937199-004	.39741335-014	.16206058-009
WME001	OT1	.100+01	.35602892-006	.36157564-009	.10155794-002
WME001	NON008	.100+01	.26914002-008	.25695522-020	.95472692-012
WME001	NON009	.100+01	.57930830-005	.55033993-011	.10730944-005
WME001	NON014	.100+01	.11686189-012	.24268827-024	.20767100-011
WME001	NON015	.100+01	.70998062-010	.15870423-016	.22353319-006
WME001	NON016	.100+01	.26624872-003	.48786068-006	.18323494-002
WME001	NON017	.100+01	.11921876-013	.87133469-019	.73087043-005
SWMT	WME005	.000	.64613797-001	.71974017-004	.11139919-002
SWMT	SWMT2	.000	.77407082+000	.42629914+000	.55072369+000
SWMT	NON001	.100+01	.11435369-005	.17274263-012	.15105996-006
SWMT	NON004	.100+01	.17994031-008	.93391119-012	.51071073-003
SWMT	NON005	.100+01	.88519010-002	.55098417-008	.62244728-006
SWMT	NON006	.100+01	.18977521-001	.95256529-009	.50194400-007
SWMT	OT1	.100+01	.18922769-002	.83165802-006	.43950133-003
SWMT	NON008	.100+01	.76835744-007	.64630080-017	.84114601-010
SWMT	NON009	.100+01	.49099912-002	.25031255-005	.51032212-003
SWMT	NON014	.100+01	.25690890-005	.18351795-010	.71433085-005
SWMT	NON015	.100+01	.22359078-003	.87405086-007	.39100287-003
SWMT	NON016	.100+01	.55405892-002	.10474053-003	.18876966-001
SWMT	NON017	.100+01	.88317497-006	.15917071-008	.18022556-002
WME005	SWMT2	.000	.61915987-001	.72747905-004	.11749373-002
WME005	NON001	.100+01	.33209471-008	.15261623-015	.45962559-007
WME005	NON004	.100+01	.21551319-010	.22274089-021	.10335379-010
WME005	NON005	.100+01	.75835765-001	.93257992-006	.12297437-004

Figure 10-4.— Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE LINEAR COMBINATION	ALL CHANNELS	RATIO
WHE005	NON006	.100+01	.26980110-001	.23929316-003	.88666193-002
WHE005	OT1	.100+01	.13227402-001	.13806314-004	.10437599-002
WHE005	NON008	.100+01	.20399093-007	.12890564-024	.63191848-017
WHE005	NON009	.100+01	.27886568-001	.37214765-005	.13345050-003
WHE005	NON014	.100+01	.22174339-002	.29909134-006	.13485919-003
WHE005	NON015	.100+01	.11360869-002	.26217832-007	.23077323-004
WHE005	NON016	.100+01	.13031358-003	.28918363-010	.21807675-006
WHE005	NON017	.100+01	.68208762-002	.32861997-005	.48178983-003
SWHT2	NON001	.100+01	.23499645-007	.13452205-015	.57256479-008
SWHT2	NON004	.100+01	.71846066-011	.33678526-015	.46875950-004
SWHT2	NON005	.100+01	.38813859-002	.14146694-008	.36497531-006
SWHT2	NON006	.100+01	.94282402-002	.32519082-008	.34491197-006
SWHT2	OT1	.100+01	.48313431-003	.28493966-006	.58977319-003
SWHT2	NON008	.100+01	.17586883-007	.51487897-018	.29276307-010
SWHT2	NON009	.100+01	.22170348-002	.52919239-006	.23869377-003
SWHT2	NON014	.100+01	.55411948-006	.17855371-011	.32222962-005
SWHT2	NON015	.100+01	.50185569-005	.15114385-009	.30116997-004
SWHT2	NON016	.100+01	.68994548-002	.71834303-005	.10411591-002
SWHT2	NON017	.100+01	.32766092-006	.35068991-009	.10702815-002
NON001	NON004	.000	.96567540-002	.39291638-005	.40688246-003
NON001	NON005	.000	.10733476-003	.21665039-013	.20184551-009
NON001	NON006	.000	.73057788-001	.97590096-009	.13357932-007
NON001	OT1	.000	.10994248+000	.38964184-002	.35602431-001
NON001	NON008	.000	.62169091-001	.33523575-009	.53923218-008
NON001	NON009	.000	.31716936-001	.57424872-005	.18105428-003
NON001	NON014	.000	.38196128-003	.15910830-010	.41655609-007
NON001	NON015	.000	.19198671-001	.37923369-006	.19804700-004
NON001	NON016	.000	.52713607-001	.31794312-004	.60315190-003
NON001	NON017	.000	.11484949-003	.15629700-011	.13608861-007
NON004	NON005	.000	.88820526-008	.26740142-016	.30105836-008
NON004	NON006	.000	.18396351-002	.24603163-009	.13410385-006
NON004	OT1	.000	.70420285-003	.17761213-005	.25221729-002
NON004	NON008	.000	.15608940+000	.84009010-003	.53821085-002
NON004	NON009	.000	.13966898-003	.31044767-009	.22227389-005
NON004	NON014	.000	.25499253-003	.34386335-007	.13511727-003
NON004	NON015	.000	.20096506-004	.74030049-010	.36837279-005
NON004	NON016	.000	.86724797-005	.66969094-013	.77220180-008
NON004	NON017	.000	.19115922-005	.70428058-010	.36842616-004
NON005	NON006	.000	.24592879-002	.55569530-012	.22595781-009
NON005	OT1	.000	.30147701+000	.72632198-004	.24092102-003
NON005	NON008	.000	.60065336-008	.36938785-026	.61497676-018

Figure 10-4.– Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE LINEAR COMBINATION	ALL CHANNELS	RATIO
NON005	NON009	.000	.43402888+000	.25878676-001	.59624319-001
NON005	NON014	.000	.86980861-001	.88524071-003	.10177420-001
NON005	NON015	.000	.25227081+000	.22426993-001	.88900468-001
NON005	NON016	.000	.53193190-004	.99548295-011	.18732089-006
NON005	NON017	.000	.23930645+000	.62247261-001	.26011526+000
NON006	OT1	.000	.10089361+000	.28719102-005	.26385657-009
NON006	NON008	.000	.64305521-001	.65547562-006	.10193197-009
NON006	NON009	.000	.21793647-001	.81322857-008	.37314937-006
NON006	NON014	.000	.60073586-001	.62405850-005	.10388235-003
NON006	NON015	.000	.42594566-002	.17109369-007	.40167963-005
NON006	NON016	.000	.38408999-002	.24112098-009	.62777079-007
NON006	NON017	.000	.11420143-001	.90757402-008	.79471336-006
OT1	NON008	.000	.24536317-002	.77847388-009	.31727419-006
OT1	NON009	.000	.34506852+000	.99511736-002	.28838259-001
OT1	NON014	.000	.11779739+000	.15221753-004	.12921979-003
OT1	NON015	.000	.5[illegible]2283+000	.48143369-001	.80666098-001
OT1	NON016	.000	.71[illegible]91729-002	.70197853-005	.98742649-003
OT1	NON017	.000	.18620431+000	.42241467-003	.22685548-002
NON008	NON009	.000	.86513818-003	.11858473-012	.13707028-009
NON008	NON014	.000	.16973706-004	.16304126-016	.96055191-012
NON008	NON015	.000	.15848668-004	.12777307-013	.80620699-009
NON008	NON016	.000	.19421453-001	.19269331-013	.99216733-012
NON008	NON017	.000	.14398528-006	.12604150-018	.87842813-012
NON009	NON014	.000	.15935208-001	.33372309-004	.20942500-002
NON009	NON015	.000	.28289650+000	.26652531-001	.94212985-001
NON009	NON016	.000	.37868602-001	.42251083-003	.11157286-001
NON009	NON017	.000	.32621982-001	.33938417-002	.10403542+000
NON014	NON015	.000	.23612721-001	.81619029-005	.34565702-003
NON014	NON016	.000	.13362534-004	.36632326-008	.27414206-003
NON014	NON017	.000	.64244708+000	.59122076-002	.92026376-002
NON015	NON016	.000	.29950261-004	.76262735-008	.25463129-003
NON015	NON017	.000	.11377798+000	.69024094-002	.60665599-001
NON016	NON017	.000	.14900115-005	.19701947-008	.71824592-003

Figure 10-4.– Continued.

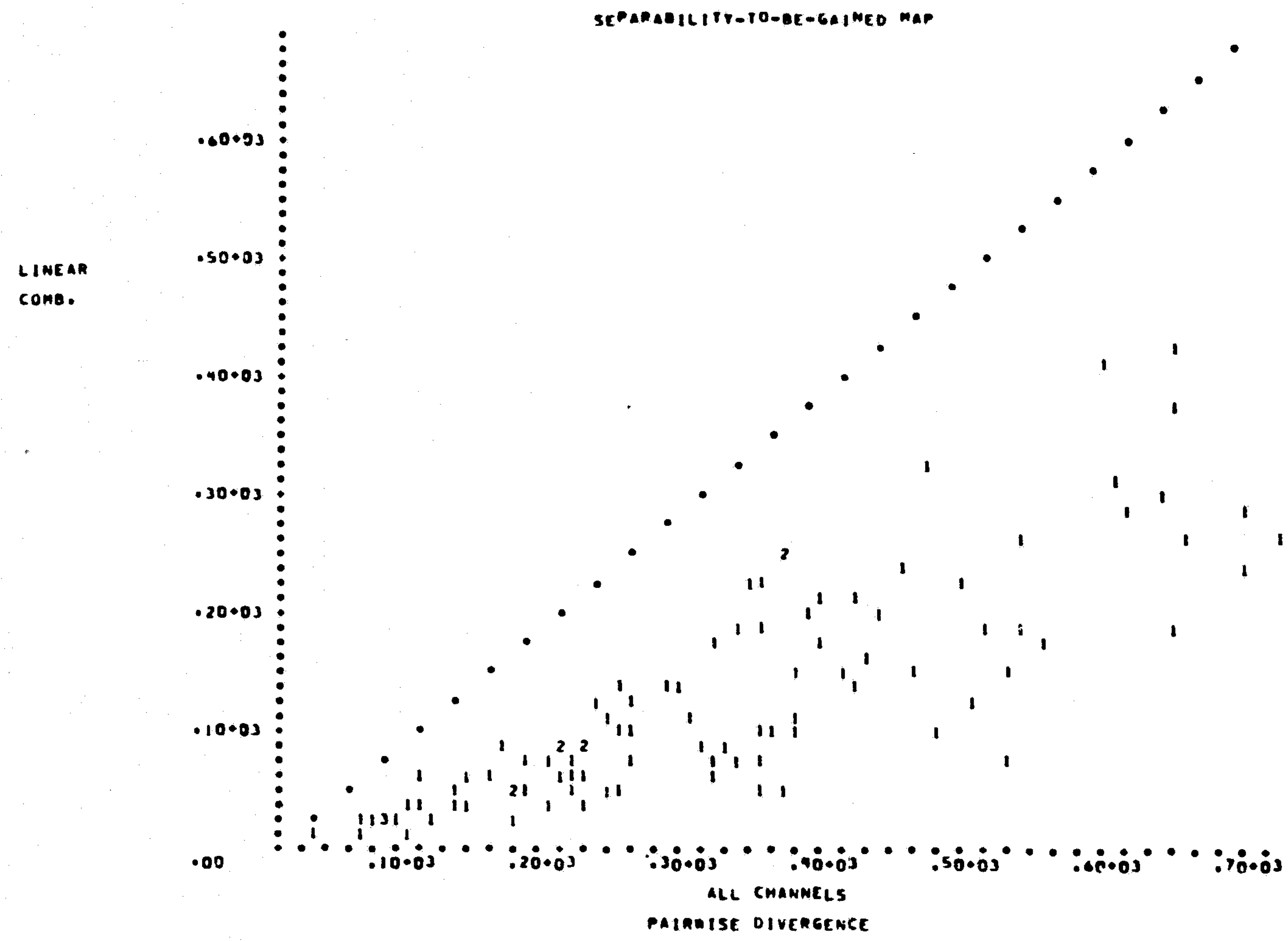


Figure 10-4.– Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

NORTON COUNTY CLUSTER STATS ON SAVTAP FILE

RESULTS FOR CHANNEL SELECTION ACTIVITY USING:
OPTIMIZATION PROCEDURE - EVAL. FEATURES REQUEST
SEPARABILITY MEASURE - WEIGHTED AV. TRANSFORMED DIVERGENCE
CHANNELS CONSIDERED - 1, 2, 3, 4, 5, 6, 7, 8, 9,10,12,13,15,16,

CHANNELS EVALUATED - 1, 5, 9,13,
SEPARABILITY MEASURE FOR EVALUATE REQUEST - .81482836+00
MINIMUM SEP.MEASURE (USING ALL CHANNELS) - .44929611-01
RATIO - .54803681-01

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE EVALUATED CHANNELS	INTERCLASS TRANSFORMED DIVERGENCE ALL CHANNELS	RATIO
WHE001	SWHT	.000	.34659435+000	.26047739-001	.75153388-001
WHE001	WHE005	.000	.54377053-003	.14123013-008	.25972376-005
WHE001	SWHT2	.000	.34842829+000	.29095142-002	.83504109-002
WHE001	NON001	.100+01	.91119354-003	.12544687-013	.13767314-010
WHE001	NON004	.100+01	.10565108-006	.15856964-016	.15008809-009
WHE001	NON005	.100+01	.19434508-007	.56826558-018	.29240030-010
WHE001	NON006	.100+01	.19268726-002	.34741335-014	.18029908-011
WHE001	OT1	.100+01	.18430109-005	.36157564-009	.19618796-003
WHE001	NON008	.100+01	.33180421-004	.25695582-020	.77441822-016
WHE001	NON009	.100+01	.23660827-004	.55833993-011	.23597650-006
WHE001	NON014	.100+01	.11394774-010	.24268827-024	.21298208-013
WHE001	NON015	.100+01	.10763035-005	.15870423-016	.14745305-010
WHE001	NON016	.100+01	.08517242-003	.40786068-006	.55114763-003
WHE001	NON017	.100+01	.48134829-009	.87133469-019	.18101959-009
SWHT	WHE005	.000	.13263248+000	.71976017-004	.54267261-003
SWHT	SWHT2	.000	.81921155+000	.42629914+000	.52357295+000
SWHT	NON001	.100+01	.31354359-001	.17274263-012	.55093666-011
SWHT	NON004	.100+01	.91650772-004	.93341119-012	.22910418-007
SWHT	NON005	.100+01	.19903223-002	.55098417-008	.38254228-005
SWHT	NON006	.100+01	.65713691-001	.95256529-009	.14495690-007
SWHT	OT1	.100+01	.21814110-002	.83165802-006	.38124779-003
SWHT	NON008	.100+01	.64590226-003	.64630080-017	.10013922-013
SWHT	NON009	.100+01	.24498702-001	.25031255-005	.10238276-003
SWHT	NON014	.100+01	.27307403-004	.18351795-010	.67204467-006
SWHT	NON015	.100+01	.97936233-002	.87405086-007	.89246935-005
SWHT	NON016	.100+01	.19284232-001	.10479053-003	.54314080-002
SWHT	NON017	.100+01	.95468912-004	.15917071-008	.16672517-004
WHE005	SWHT2	.000	.14990061+000	.72747405-004	.48692845-003
WHE005	NON001	.100+01	.69465534-002	.15261623-015	.21970065-013
WHE005	NON004	.100+01	.15603411-003	.22274089-021	.14275191-017
WHE005	NON005	.100+01	.52135032-001	.93257942-006	.17887769-004

Figure 10-4.– Continued.

10-37
234

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE EVALUATED CHANNELS	ALL CHANNELS	RATIO
WHE005	NON006	.100+01	.14185701+000	.23929316-003	.16868617-002
WHE005	OT1	.100+01	.29390605-001	.13806314-009	.46975265-003
WHE005	NON008	.100+01	.29142994-003	.12890569-024	.44232255-021
WHE005	NON009	.100+01	.66498783-001	.37214765-005	.55963077-004
WHE005	NON014	.100+01	.86413503-002	.29904134-006	.34605857-004
WHE005	NON015	.100+01	.59117376-001	.26217832-007	.44348813-006
WHE005	NON016	.100+01	.17098867-002	.28918363-010	.16620027-007
WHE005	NON017	.100+01	.65352840-002	.32861997-005	.50283889-003
SWHT2	NON001	.100+01	.98549810-002	.13452205-015	.13650158-013
SWHT2	NON004	.100+01	.65683016-005	.33678526-015	.51274329-010
SWHT2	NON005	.100+01	.96188045-003	.14146694-008	.14707330-005
SWHT2	NON006	.100+01	.67079229-001	.32519082-008	.48478620-007
SWHT2	OT1	.100+01	.13760088-002	.28493966-006	.20707692-003
SWHT2	NON008	.100+01	.71560635-003	.51487897-018	.71950029-015
SWHT2	NON009	.100+01	.10557512-001	.52919239-006	.50124724-004
SWHT2	NON014	.100+01	.66512760-005	.17855371-011	.26845031-006
SWHT2	NON015	.100+01	.42126812-002	.15114385-009	.35878302-007
SWHT2	NON016	.100+01	.11789992-001	.71834303-005	.60928204-003
SWHT2	NON017	.100+01	.22169107-004	.35068991-009	.15818833-004
NON001	NON004	.000	.31181553+000	.39291638-005	.12600924-004
NON001	NON005	.000	.25914051-001	.21665039-013	.83603443-012
NON001	NON006	.000	.63319750+000	.97590096-009	.15412268-008
NON001	OT1	.000	.33802853+000	.38969189-002	.11526892-001
NON001	NON008	.000	.13449323+000	.33523575-009	.24925846-008
NON001	NON009	.000	.84150724-001	.57424872-005	.68240513-004
NON001	NON014	.000	.68165941-002	.15910930-010	.23341319-008
NON001	NON015	.000	.15227859-001	.37923369-006	.24903940-004
NON001	NON016	.000	.21880080+000	.31794312-004	.14531168-003
NON001	NON017	.000	.61885785-002	.15629700-011	.25255719-009
NON004	NON005	.000	.11209838-001	.26740162-016	.23854192-014
NON004	NON006	.000	.20166565+000	.24603163-009	.12199977-008
NON004	OT1	.000	.12714361+000	.17761213-005	.13969411-004
NON004	NON008	.000	.17795216+000	.84009010-003	.47208761-002
NON004	NON009	.000	.11728043-002	.31044767-009	.26470544-006
NON004	NON014	.000	.13492565-001	.34386335-007	.25580190-005
NON004	NON015	.000	.30271799-003	.74030099-010	.24455121-006
NON004	NON016	.000	.32439168-002	.66969094-013	.20649684-010
NON004	NON017	.000	.11986645-001	.79428058-010	.58755340-008
NON005	NON006	.000	.11991876+000	.55569530-017	.46339319-011
NON005	OT1	.000	.66493193+000	.72632198-009	.10931966-008
NON005	NON008	.000	.24193787-003	.36938785-024	.15299499-022

Figure 10-4.— Continued.

SAMPLE RUN FOR SELECT
ALL OPTIONS USED

AUG. 25,1975

MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

INTERCLASS SEPARABILITY TABLE

SUBCLASS PAIR		WEIGHT	INTERCLASS TRANSFORMED DIVERGENCE EVALUATED CHANNELS	INTERCLASS TRANSFORMED DIVERGENCE ALL CHANNELS	RATIO
NON005	NON009	.000	.54915198+000	.25878674-001	.47124799-001
NON005	NON014	.000	.12001554+000	.88524071-003	.73768508-002
NON005	NON015	.000	.41991349+000	.22426493-001	.24379459-001
NON005	NON016	.000	.16491219-003	.99548295-011	.60364442-007
NON005	NON017	.000	.30168338+000	.62247261-001	.20633308+000
NON006	OT1	.000	.36867089+000	.28719102-005	.77899023-005
NON006	NON008	.000	.21811892+000	.65547562-006	.30051295-005
NON006	NON009	.000	.23919413+000	.81322857-008	.33998684-007
NON006	NON014	.000	.34446900-001	.62405850-005	.18116536-003
NON006	NON015	.000	.10907744+000	.17109369-007	.15685525-006
NON006	NON016	.000	.19191864+000	.24112098-009	.12596499-008
NON006	NON017	.000	.51015161-001	.90757402-008	.17790280-006
OT1	NON008	.000	.18349924-001	.77847388-009	.42423820-007
OT1	NON009	.000	.41476195+000	.99511736-002	.23992499-001
OT1	NON014	.000	.25132686+000	.15221753-004	.60565566-004
OT1	NON015	.000	.50935312+000	.48193369-001	.95455679-001
OT1	NON016	.000	.32003176-001	.70197853-005	.21934652-003
OT1	NON017	.000	.34812836+000	.42241467-003	.12133877-002
NON008	NON009	.000	.70053735-002	.11858473-017	.16927681-010
NON008	NON014	.000	.11733725-004	.16304126-016	.13895098-011
NON008	NON015	.000	.43396445-003	.12777307-013	.29443212-010
NON008	NON016	.000	.12058365+000	.19269331-013	.15980053-012
NON008	NON017	.000	.40766882-004	.12604150-018	.30917622-014
NON009	NON014	.000	.24437369-001	.33372309-004	.13656261-002
NON009	NON015	.000	.64580512+000	.26652531-001	.41270239-001
NON009	NON016	.000	.25696195-001	.42251083-003	.16442545-001
NON009	NON017	.000	.51931173-001	.33938417-002	.67929128-001
NON014	NON015	.000	.19484643+000	.81619029-005	.41888909-004
NON014	NON016	.000	.19672728-004	.36632326-008	.18620867-003
NON014	NON017	.000	.71148701+000	.59122076-002	.83096494-002
NON015	NON016	.000	.21306247-002	.76262735-008	.35793603-005
NON015	NON017	.000	.30135930+000	.69024099-002	.22904252-001
NON016	NON017	.000	.14334731-004	.10701947-008	.74657465-004

Figure 10-4.— Continued.

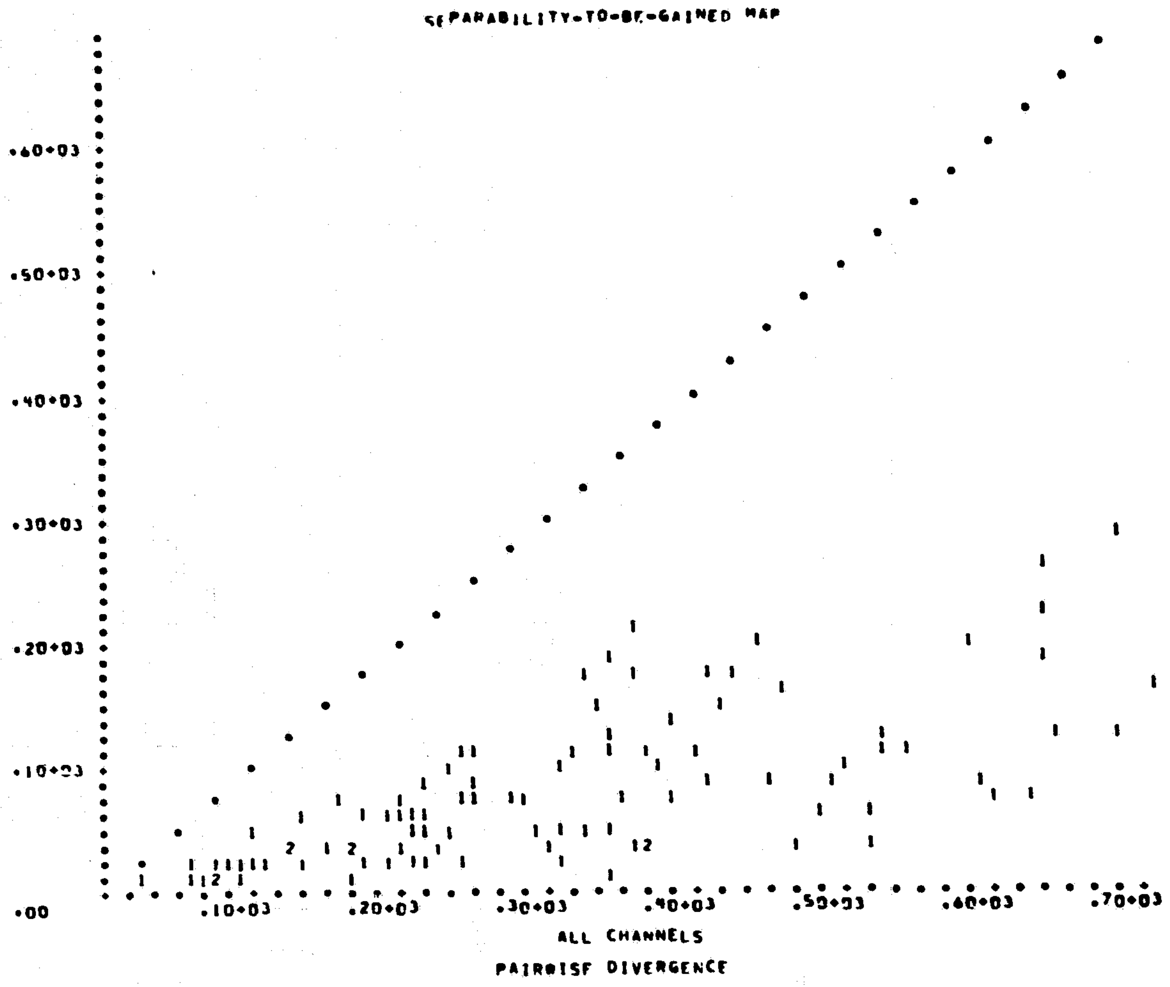


Figure 10-4.- Continued.

```
                                   SAMPLE RUN FOR SELECT                                AUG. 25.1975
                                     ALL OPTIONS USED
              MORTON COUNTY CLUSTER STATS ON SAVTAP FILE

$SELECT
  $END.
TIME FOR SELECT      5.699
```

Figure 10-4.– Concluded.

11. CLASSIFICATION PROCESSOR — CLASSIFY

The classification processor CLASSIFY classifies the MSS image data based on statistics (mean vectors and covariance matrices) computed from the training fields.

11.1 PROCEDURES

Given the statistics for each subclass of interest, each data point within the defined classification field from the MSS data tape (DATAPE) is assigned to a subclass by one of two procedures.

In the first procedure, the user does not define categories in his input, and the standard m-class maximum likelihood classification rule is followed. However, to decrease the number of times the density function must be computed, the classification-by-thresholding procedure proposed by Hallum and Minter (ref. 8) and improved upon and implemented by Feiveson (ref. 9) is used. The standard classification rule (i.e., when no categories are defined by the user) is outlined in section 11.1.1.

In the second procedure, the user defines categories in his input, and the sum-of-normal-densities classification rule is followed, as set out in section 11.1.2.

11.1.1 STANDARD M-CLASS CLASSIFICATION

Assuming multivariate normal probability density functions and using the maximum likelihood classification rule, the data vector $X^T = (X_1, X_2, X_3, \cdots, X_N)$ is assigned to subclass i in the following manner.

The assumed joint probability density function of X, when material of type i fills the MSS field of view, is given in the following equation.

$$p_i(X) = \frac{P_i}{(2\pi)^{N/2}|K_i|^{1/2}} e^{-0.5Q_i} \tag{11-1}$$

where:

P_i = *a priori* probability for subclass i

N = number of channels used for classification

K_i = covariance matrix for subclass i

X = data vector $(X_1, X_2, X_3, \cdots, X_N)$

$Q_i = (X - \mu_i)^T K_i^{-1} (X - \mu_i)$

μ_i = mean vector for subclass i

Because of the exponential form of p_i and because $\ell n(p_i)$ is a monotonically increasing function of p_i, for computational purposes it is convenient to define a new function V_i by

$$V_i = \ell n(p_i) = \ell n(P_i) - \frac{N}{2}\ell n(2\pi) - \frac{1}{2}\ell n|K_i| - \frac{1}{2}(X - \mu_i)^T K_i^{-1}(X - \mu_i) \tag{11-2}$$

The data vector X is classified as belonging to subclass i if $V_i > V_j$ for all $i \neq j$, where $j = 1,2,3,\cdots,n$ and n = number of subclasses.

The number of times the function V_i must be computed may be reduced by the use of thresholds; i.e., real numbers γ_{ij} (independent of X) such that

$$\left.\begin{array}{ll} & V_i(X) > \gamma_{ij} \text{ implies } V_i(X) > V_j(X) \\ \text{and} & V_j(X) > \gamma_{ij} \text{ implies } V_j(X) > V_i(X) \end{array}\right\} \tag{11-3}$$

where $i,j = 1,2,3,\cdots,n$ and $i \neq j$.

The utility of these thresholds is that, if $V_i(X) > \gamma_{ij}$, $V_j(X)$ need not be computed. Once the values for γ_{ij} have been determined, they may be used for each observation vector X.

11.1.2 SUM-OF-NORMAL-DENSITIES CLASSIFICATION

Also, assuming multivariate normal probability density functions, the category classifier classifies the data vector $X^T = (X_1, X_2, X_3, \cdots, X_N)$ to category j and subclass i in the following manner.

The probability density function for each category j is computed by the following equation.

$$p_j(X) = \sum_{i=1}^{k_j} \frac{P_i}{(2\pi)^{N/2}|K_i|^{1/2}} e^{-0.5Q_i} \tag{11-4}$$

where

i = subclass number

j = category number

k_j = number of subclasses in category j

P_i = *a priori* probability for subclass i in category j

N = number of channels used for classification

Having computed the probability density function for all categories, the data vector X is classified as belonging to category j if $p_j > p_\ell$, where $\ell = 1,2,3,\cdots,q$ for all $j \neq \ell$ and q = number of categories.

The data vector is classified as belonging to subclass i if the probability density function for subclass i in category j is such that $p_{ji} > p_{jm}$ for all $i \neq m$, where $m = 1,2,3,\cdots,k_j$. In the computation of p_j, if the value of the quadratic form Q_i is smaller than -88, the computer cannot store the computed value of e^{Q_i}. Thus, $e^{Q_i} = 0$ for all $Q_i \leq -88$. In the case

of all $P_j = 0$ for $j = 1,2,3,\cdots,q$, the data point will not be classified; it will be assigned to a null subclass.

When the line printer map of the classified data is displayed, each data point is printed with the symbol representing the legitimate subclass to which the data point belongs, and the null subclass is printed with the blank symbol. Figure 11-1 gives the functional flow of the CLASSIFY processor.

11.2 INPUT FILES

An MSS data tape (DATAPE) must be input to the CLASSIFY processor. The tape assignment defaults to logical unit C (Fortran unit 3); however, by input of the DATAFILE control card, the user may assign any available logical unit. (See table 4-1 for file assignments and section 3.2, MSS Image Data Tapes, for further information on format.)

11.3 OUTPUT FILES

The classification results are output on the MAPTAP file (see appendix C) which is assigned to logical unit B (Fortran unit 2). In the event of card input of the module STAT deck, the statistics will be output on the SAVTAP file (see section 4.1).

11.4 SCRATCH FILES

The processor requires no scratch file.

11.5 CARD INPUT

All required input card types are described below.

11.5.1 PROCESSOR CARD

The processor keyword is left justified beginning in column 1; the parameter FILE is punched starting in column 11. For example,

$CLASSIFY FILE=N

This card directs the system monitor routine to load all routines used by the CLASSIFY processor. The parameter FILE=N informs the processor to output the current classification results on file N of MAPTAP. If no integer file number is specified, the processor defaults to file 1 of MAPTAP.

11.5.2 SPECIAL SYSTEM DECKS

The training statistics may be input by means of the module STAT deck. The B-transformation matrix may be input by means of the B-matrix card deck. The EOD-LARSYS deck formats are described in section 3.1.

11.5.3 CONTROL CARDS

The cards described in table 11-1 are the complete set of control cards recognized by the CLASSIFY processor. All options available to the user are exercised by use of the appropriate processor control card. If a default condition is specified, the control card is optional. If no default condition is specified, the control card is mandatory input. Ordering of the sequence of processor control cards is unnecessary, with the exceptions that (1) the *END* card must follow the last processor control card, (2) the $END* card must follow the last field definition card for an area to be classified, and (3) the STATFILE control card must precede the input of the module STAT deck in some cases. See table 11-1.

11.5.4 FIELD DEFINITIONS

Areas to be classified are communicated to the classification processor by using the field definition data card described in section 3.1.3, which contains the scan line and sample coordinates for the area over which classification is to be performed. At least one field definition card must be in the run deck immediately following the *END* control card. As many field definition cards as there are areas to be classified may be input. The processor will classify each field in the order it is identified, will print on the line printer the first 110 samples of the classification map, and will print any optional output prescribed by the control cards for each field classified. The scan line and sample coordinates specified on the field definition card must be available on the input MSS data tape (DATAPE).

11.5.5 DECK SETUP

The deck setup for the CLASSIFY processor is given in figure 11-2. The @ in column 1 indicates the master punch for the Univac system, which is the 7-8 multipunch.

11.6 CARD OUTPUT

The classification processor outputs no punched cards.

11.7 SAMPLE COMPUTER RUNS

The first sample test run (fig. 11-3) illustrates the manner in which most of the available CLASSIFY options are exercised. The SAVTAP file, which has been created by a previous execution of the STAT processor, is read from tape. SAVTAP contains descriptions and statistics for 23 fields, 8 classes, and 9 subclasses. The class-subclass correspondence is as follows.

Class number	Class name	Subclass number	Subclass name
1	SOYBN1	1	SOYBN1
2	CORN	2	CORN
3	OATS	3	OATS
4	WHEAT	4	WHT1
		5	WHT2
5	RDCL1	6	RDCL1
6	ALFALF	7	ALFALF
7	RYE	8	RYE
8	BRSOIL	9	BRSOIL

The grouping option combines subclasses 4 and 5 (WHT1 and WHT2) to form a new subclass WHEATS, and the number of subclasses used in classification will be eight. Note that WHEATS is a new subclass belonging to the class WHEAT, and the class name WHEAT – not the subclass name WHEATS – goes on the CATEGORY control card.

Figure 11-4 is a sample computer program listing using all default options. No output is provided.

11.8 RESTRICTIONS

The system-related restrictions described in section 17, along with the following, apply to the CLASSIFY processor.

The category, class, and subclass relationship is as follows:

$$\begin{matrix}\text{Number of}\\ \text{categories}\end{matrix} \le \begin{matrix}\text{Number of}\\ \text{classes}\end{matrix} \le \begin{matrix}\text{Number of}\\ \text{subclasses}\end{matrix} \le 60 \qquad (11\text{-}5)$$

The size of the B-matrix cannot exceed 450 locations:

$$\begin{pmatrix}\text{Number of linear}\\ \text{combinations}\end{pmatrix}\begin{pmatrix}\text{Number of chan-}\\ \text{nels in B-matrix}\end{pmatrix} \le 450 \qquad (11\text{-}6)$$

The channels used in computing the B-matrix automatically replace the channels, if any, on the CHANNELS control card.

The largest sample number of the classification field minus the smallest sample number of the classification field cannot exceed 1000.

Beginning with the smallest sample number of the classification field, only the next 110 samples are displayed on the line-printer map output by CLASSIFY, but the entire classified field is displayed on the line-printer map output by DISPLAY.

When applying the category classifier option, 12 500 storage locations are reserved for the data such that

$$\left(\frac{\text{Sample end} - \text{sample start}}{2 + 1}\right)\left(\begin{matrix}\text{Number of}\\ \text{channels}\end{matrix}\right) \leq 12\ 500 \qquad (11\text{-}7)$$

When applying the standard classifier option, the table computed for the class-pair thresholding procedure shares this storage of 12 500 locations reserved for the data such that

$$\left[\left(\begin{matrix}\text{Number of}\\ \text{subclasses}\end{matrix} - 1\right)\frac{\left(\begin{matrix}\text{Number of}\\ \text{subclasses}\end{matrix} - 2\right)}{2} + \begin{matrix}\text{Number of}\\ \text{subclasses}\end{matrix}\right]$$

$$+ \left(\frac{\text{Sample end} - \text{sample start}}{2 + 1}\right)\begin{matrix}\text{Number of}\\ \text{channels}\end{matrix} \leq 12\ 500 \qquad (11\text{-}8)$$

11.9 DIAGNOSTIC MESSAGES

The diagnostic messages and the routines in which they appear are as follows.

11.9.1 CLSFY1 ROUTINE

Message	Explanation
***** CLSFY/CLSFY1/CLSF1A --- THE COVARIANCE MATRIX FOR SUB-CLASS NO. XX IS EITHER SINGULAR OR NOT POSITIVE DEFINITE - THE DETERMINANT = XXXX.XXXX	The determinant of each sub-class covariance matrix is checked by CLASSIFY to see that it is a positive nonzero value. A zero value indicates a singular

Message	Explanation
***** TERMINATING PROGRAM EXECUTION *****	matrix, and a negative value i indicates a nonpositive definite matrix. If either condition occurs for any subclass covariance matrix to be used in classification, the processor will stop.[1]

11.9.2 CLSFY2 ROUTINE

Message	Explanation
WIDTH OF RECTANGULAR FIELD SURROUNDING CLASSIFICATION FIELD CANNOT EXCEED 1000 POINTS.	The largest sample of the classification field minus the smallest sample of the classification field cannot exceed 1000 samples. Reduce amount of samples per scan line.
TOO MUCH DATA REQUESTED.	When too much data has been requested, (1) for the standard classifier, reduce parameters so that $\left(\text{Number of subclasses} - 1\right)\left(\text{Number of subclasses} - 2\right) + \text{Number of subclasses} + \left(\text{Points per scan line}\right) \times \left(\text{Number of channels}\right) \le 12\ 500$; or (2) for category classifier, reduce data so that points per

[1] A probable source of an invalid covariance matrix is a module STAT deck which has been incorrectly formatted and thus is not producing good training class statistics. Another possible source is that the SAVTAP file does not contain valid statistical data.

Message	Explanation
	scan line × number of channels $\leq$ 12 500.

11.9.3 REDIF2 ROUTINE

Message	Explanation
***** CLSFY/REDIF2 --- BAD CARD INPUT DETECTED ON ATTEMPT TO READ B-MATRIX INFORMATION AS DIRECTED BY THE CONTROL CARD ··· 'CCCC ··· CCCC' ***** TERMINATING PROGRAM EXECUTION FROM REDIF2 *****	The input B-MATRIX control card is printed out as part of the error message. One of the data cards following it is incorrectly formatted. Check deck setup and B-matrix card deck.
** CLSFY/REDIF2 -- B-MATRIX INPUT FROM BMFILE - BAD INPUT VALUES DETECTED: NO. COMBINATIONS (BMCOMB) = _____, NO. CHANNELS (BMFEAT) = _____, CHANNEL VECTOR (FETVC2) = ____.	Invalid data from the BMFILE has been deleted.
AT LEAST TWO (2) CATEGORIES MUST BE ASSIGNED. EXITING FROM REDIF2.	In exercising the category option, two or more categories must be used.

11.9.4 SETUP2 ROUTINE

Message	Explanation
***** CLSFY/SETUP2 ··· ERROR CONDITION ON ATTEMPT TO POSITION MAPTAP TO FILE NO. XX ***** ERROR STATUS CODE = YY --- ABORTING THE RUN *****	The CLASSIFY processor attempted to position the output classification results file (MAPTAP) to the file number specified on the $CLASSIFY processor card. Possibly (1) more files were

Message	Explanation
	indicated than currently existed on the MAPTAP file, (2) bad tape if the file is assigned to tape, or (3) the format of the $CLASSIFY processor card is incorrect.
AN ERROR HAS OCCURRED IN GROUPING CLASSES INTO CATEGORIES. CHECK THE FOLLOWING: NOT ALL OF THE CLASSES HAVE BEEN ASSIGNED TO A CATEGORY. A CLASS NAME ON THE CATEGORY CARD HAS BEEN MISSPELLED. CLASS NAMES FROM SAVTAP FILE ARE: __________. CLASS NAMES FROM CATEGORY CARDS ARE: __________.	When an error occurs in grouping classes into categories, either one or more class names (1) have not been assigned or (2) have been misspelled. The program lists the class names as submitted from the SAVTAP file or cards. Check these for errors. If neither (1) nor (2) is applicable, check the module STAT deck to assure that class names are left justified in the field.

TABLE 11-1.— CLASSIFY PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
SUBCLASS	$K_1, K_2, \cdots, K_i$ $1 \le K_i \le 60$; i = number of subclasses in training statistics Default: All the training subclasses are used.	K's are integers comprising the set of subclass numbers used by the processor to classify the unknown data points; must be a subset of training subclasses designated as they occur on the SAVTAP file.
CHANNELS	$STAT=N_1, N_2, \cdots, N_k,$ $DATA=M_1, M_2, \cdots, M_k$ $k \le 30$ Default: (1) If executed back to back with SELECT, the channels selected by the SELECT processor are used; (2) If a B-matrix is input, the channels used in computing the matrix are used; (3) Otherwise, all channels in the training statistics are used.	$N_1, N_2, \cdots, N_K$ are the channel numbers (integers) from the SAVTAP file to be used in classification; $M_1, M_2, \cdots, M_K$ are the channel numbers (integers) from the MSS data tape (DATAPE). The number of channels selected from SAVTAP and DATAPE must be equal.
CATEGORY	$CATNAM/NAME_1, NAME_2, \cdots$ Default: If no	Informs the processor that the category classifier option

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

Keyword	Parameter and default values	Function
	categories are defined, the standard classifier is applied.	will be applied and defines one category name (CATNAM) and the class names ($NAME_i$'s) for this category. All subclasses for a class are assigned to this category. CATNAM and $NAME_i$ may be up to six characters, and $NAME_i$ must match a class name on the SAVTAP file. A slash (/) separates the category name from the class name. Note: (1) Every class must be assigned to a category unless the class was eliminated by omitting all of its subclasses on the SUBCLASS control card; (2) At least two categories must be defined; (3) Continuation of the list of class names in the category on another card is indicated by an asterisk after the last class name of that card. The next card should continue the list of class names in columns 11-72. (See test example in section 11.6.)
GROUP	SUBNAM,K_1,K_2,$\cdots$,K_i $1 \leq K_i \leq 60$; i=number of training subclasses	K_i's are integer subclass numbers taken from the set of available training subclasses.

TABLE 11-1.– Continued.

Keyword	Parameter and default values	Function
	Default: Subject to the SUBCLASS control card, each individual training subclass is used as a possibility for unknown data sample classification	The processor creates a new training subclass by combining the statistics of the training subclasses listed. The training subclasses used are not thereafter available as individual subclass possibilities for an unknown data sample. The set of training subclasses to be used is renumbered by the processor to account for the new grouped subclass and the training subclasses deleted by grouping. The revised set of training subclasses is used for all processor output. SUBNAM may be from one to six characters and will become the name for a new training subclass.
DATAFILE	UNIT=N,FILE=M Default: N=3,M=1	N is the Fortran logical unit number to which the MSS data tape (DATAPE) has been assigned; M is the file number of the tape to be processed. For back-to-back executions of several processors, if using the same file number, only one DATAFILE control card need be input.

TABLE 11-1.- Continued.

Keyword	Parameter and default values	Function
STATFILE	UNIT=N,FILE=M Default: N=1,M=1	N is the Fortran logical unit number to which the SAVTAP file has been assigned; M is: (1) the number of the file to be processed or (2), if the module STAT deck is input, the number of the file for storing the statistics. If M≠1, this control card must precede the module STAT deck in the control card deck setup.
MODULE	Blank Default: Training subclass statistics are read from the input file SAVTAP.	Indicates to the processor that the training subclass statistics will be input on cards. The module STAT deck must immediately follow this control card. See section 3.1.4.1 for further details.
B-MATRIX	CARDS or FILE Default: No transformation of training subclass covariance matrices	Informs the processor that the B-transformation matrix is to be input and applied to the training subclass statistics prior to classification. If FILE is placed in the parameter field, the mode of B-matrix input will be from BMFILE; if CARDS is specified, the B-matrix card deck must immediately follow this control

TABLE 11-1.– Continued.

Keyword	Parameter and default values	Function
		card. The channels which were used to derive the B-transformation matrix will be the channels used by the processor in classification. (See section 3.1.4.2 for further details.)
APRIORI	$A_1, A_2, \cdots, A_M$ or $N*A_i, K*A_{N+1}, \cdots, A_M$ $M \leq 60$ Default: If executing the standard classifier, each subclass is given an equal *a priori* value. If executing the category classifier, each category is given an equal *a priori* value which is divided equally among the subclasses in that category.	*A priori* values may be input by subclass, class, or category. N and K are arbitrary repetition factors, and A_i's are decimal numbers such that $\sum_{i=1}^{M} A_i = 1.0$ M = number of training subclasses, training classes, or categories. If input by class or category, the setup routine will distribute the *a priori* values among the subclasses in the following manner: By class = $\frac{\text{Class } a\ priori \text{ values}}{\text{Number of subclasses in that class}}$ By category = $\frac{\text{Category } a\ priori \text{ values}}{\text{Number of subclasses in that category}}$ The order in which the A_i's are input must be the order in which

TABLE 11-1.— Concluded.

Keyword	Parameter and default values	Function
		the category, class, or subclass was defined.
OPTION	STATS Default: No training subclass statistics printout	Training statistics will be printed out for each subclass, reflecting the B-transformation, if any, and the Cholesky factorization of the covariance matrices.
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of card input for the processing function.

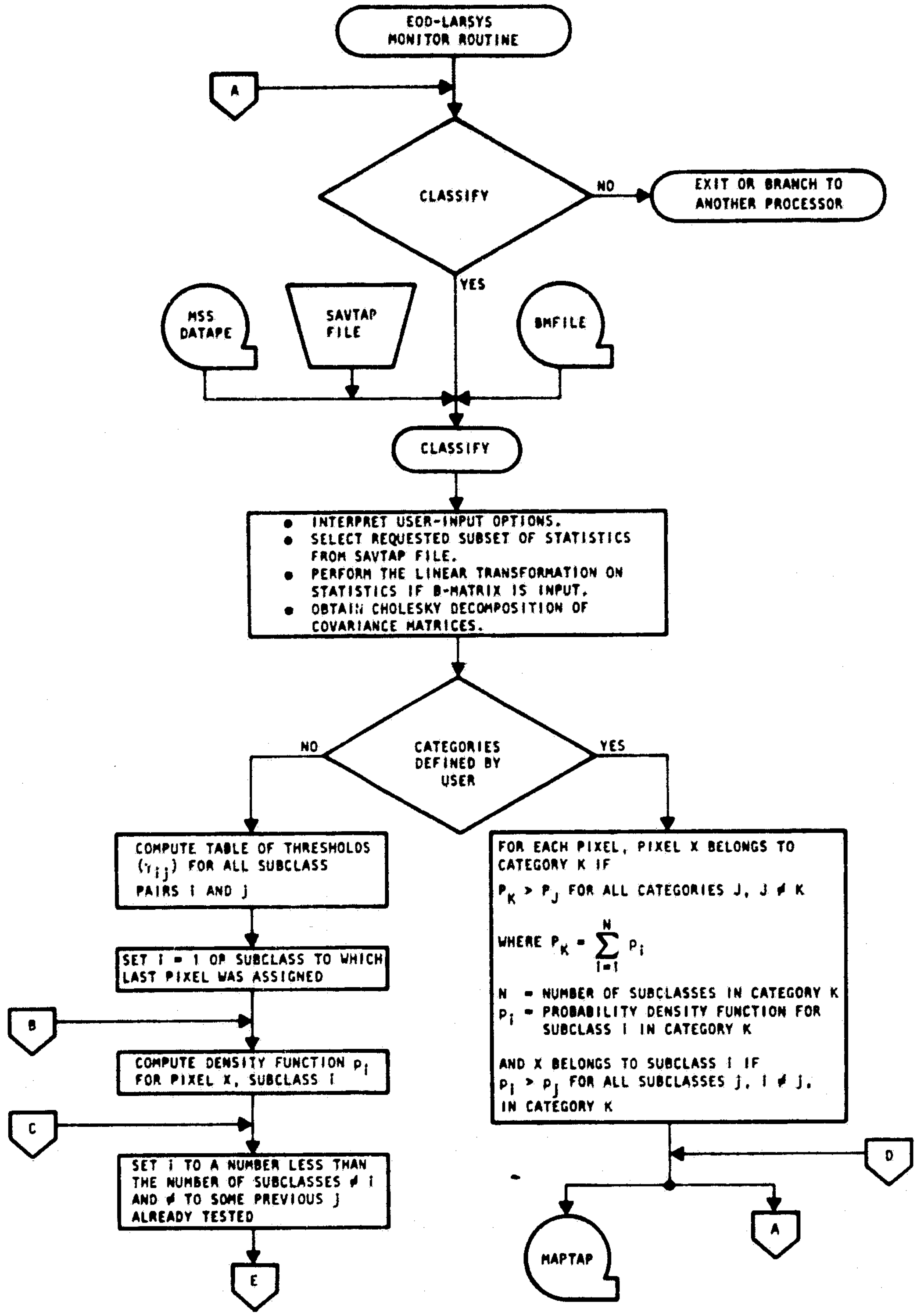


Figure 11-1.– Functional flow chart for the CLASSIFY processor.

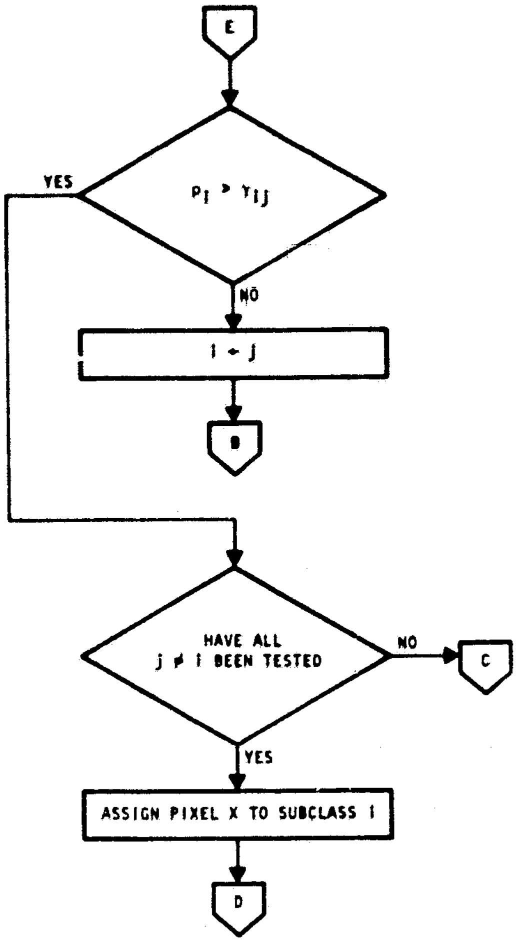
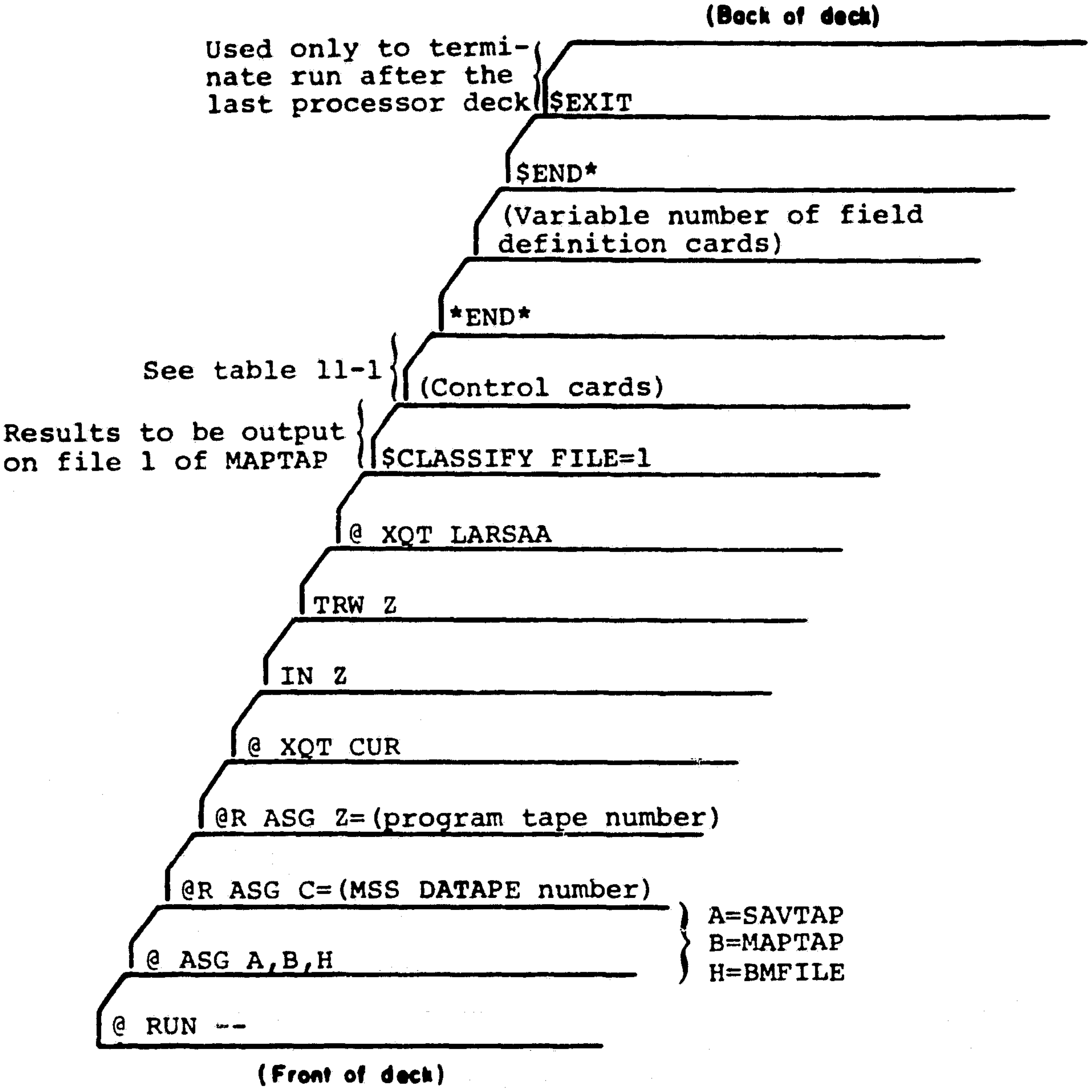
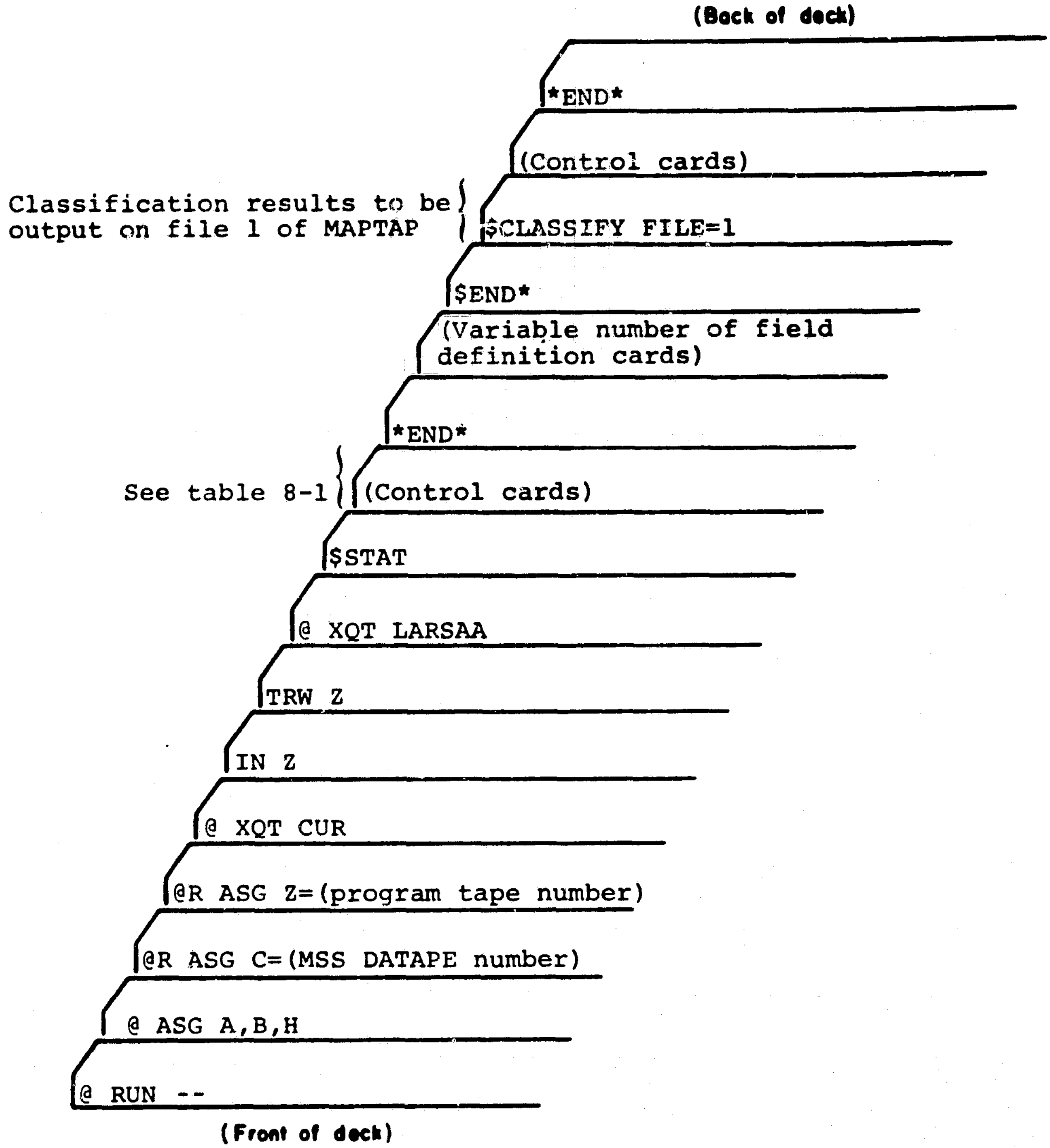


Figure 11-1.– Concluded.



(a) For independent execution with all possible files assigned.

Figure 11-2.– Deck setup for the CLASSIFY processor.



(b) For execution back to back with the STAT and DISPLAY processors.

Figure 11-2.— Continued.

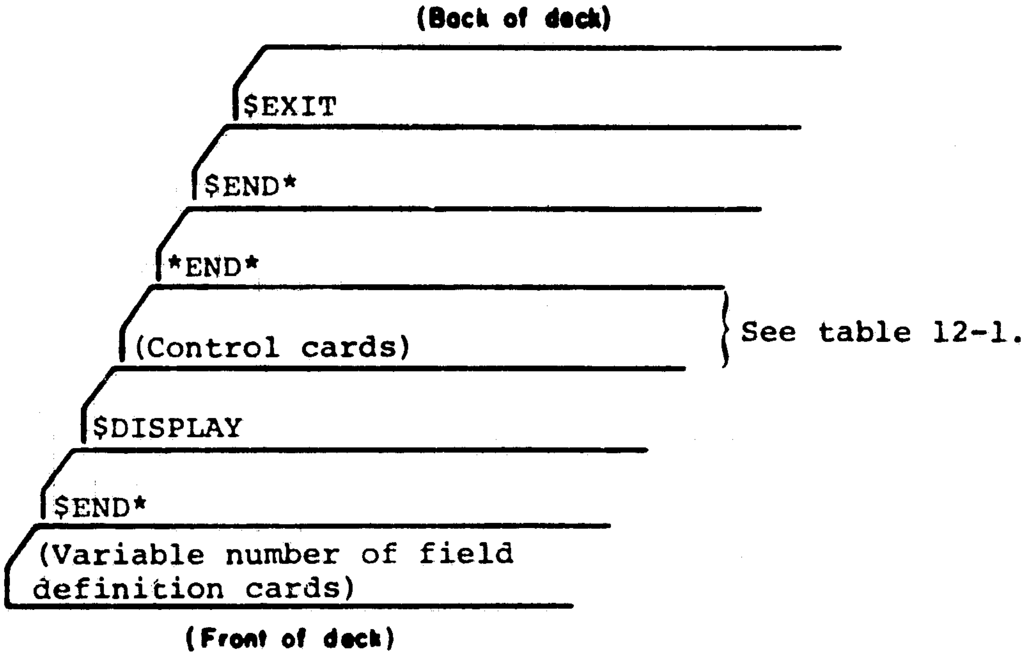


Figure 11-2.— Concluded.

Card	Sample program listing		Comment/command
1	@Z RUN L78362,TF7,H4,1659,C087,C,15,5C0	WILLS	EXEC 2 run card
2	@N MSG TAPES 4		Message to operator (optional)
3	@ ASG Z=V10394		Assign EOD-LARSYS program tape
4	@ ASG A=V10680		Assign SAVTAP file
5	@ ASG B=B		Assign a scratch tape for the classification output file
6	@ ASG C=V03662		Assign MSS DATAPE
7	@ XCT CUR		Execute Univac tape complex utility routines
8	TRW Z		Rewind program tape
9	IN Z		Read program tape into system
10	TRI Z		Rewind program tape with interlock
11	@ XCT LARSAA		Execute EOD-LARSYS
12	$CLASSIFY		Execute CLASSIFY processor
13	HED1 CLASSIFYING FLIGHT LINE C1 DATA		First line of heading for line printer output
14	HED2 EXERCISING ALL OPTIONS EXCEPT B-MATRIX		Second line of heading for line printer output
15	DATE AUG. 30,1975		Date used in line printer output
16	OPTION STATS		Print the statistics
17	SUBCLASSES1,2,3,4,5,6,7,8,9		Statistics for subclasses 1-9 will be read into core from SAVTAP file
18	GROUP WHEATS,4,5		Statistics for subclasses 4 and 5 are combined to form subclass WHEATS
19	CHANNEL 1,9		Channels 1 and 9 will be used in classification of data
20	COMMENT APRIORI VALUES INPUT BY CATEGORIES		Third line of heading for line printer output
21	APRIORI .63,.37		*A priori* values for category WHEAT=.63 and for category NONWH=.37
22	CATEGORY WHEAT/WHEAT		Class WHEAT is assigned to category WHEAT (first category)
23	CATEGORY NON-WH/SOYBN1,CORN,OATS*		Classes SOYBN1, CORN, OATS, RDCL1, ALFALF, RYE, and BRSOIL are
24	RDCL1,ALFALF,RYE,BRSOIL		assigned to category NONWH (second category)
25	*END*		End of control card input
26	FIELD (2,2),(1,1),(220,1),(223,950),(1,950)		Define classification field
27	$END*		End of field definition card input
28	$EXIT		Exit EOD-LARSYS
29	@ PMD		Give core dump if run errs

Figure 11-3.– Sample program listing and output for the CLASSIFY processor using all options except B-MATRIX and CHANNELS default.

```
$CLASSIFY
    HED1          CLASSIFYING FLIGHT LINE C1 DATA
    HED2             EXERCISING ALL OPTIONS EXCEPT B-MATRIX
    DATE      AUG. 30,1975
    OPTION    STATS
    SUBCLA    1,2,3,4,5,6,7,8,9
    GROUP     WHEATS,4,5
    CHANNE    1,9
    COMMEN              APRIORI VALUES INPUT BY CATEGORIES
    APRIOR    .63,.37
    CATEGO    WHEAT/WHEAT
    CATEGO    NON-WH/SOYBNI,CORN,OATS*
              RDCLI,ALFALF,RYE,BRSOIL
    *END*
```


Figure 11-3.— Continued.

```
                 CLASSIFYING FLIGHT LINE C1 DATA                              AUG. 30,1975
                   EXERCISING ALL OPTIONS EXCEPT B-MATRIX

           APRIORI VALUES INPUT BY CATEGORIES

THE FOLLOWING OPTIONS HAVE BEEN SELECTED

   PRINT MULTISPECTRAL STATISTICS.
   CATEGORY CLASSIFIER OPTION HAS BEEN SELECTED.
   APRIORI VALUES INPUT BY CATEGORY.  APRIOR(I) = CATEGORY(J) APRIORI / (NO. SUBCLASSES IN CATEGORY(J))

SUPERVISOR INFORMATION :

   FILE NUMBER ...          1
   NO. OF FIELDS . .. .    23
   NO. OF CLASSES........   8
   NO. OF SUBCLASSES.....   8
   NO. OF CHANNELS.......   2
```

Figure 11-3.– Continued.

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

AUG. 30,1975

APRIORI VALUES INPUT BY CATEGORIES

SAVED TRAINING FIELDS

FIELD		CLASS		SUBCLASS		VERTICES (SAMPLE,LINE)			
1	25-6	1	SOYBNI	1	SOYBNI	(69, 65)	(89, 65)	(89, 81)	(69, 81)
2	31-13	1	SOYBNI	1	SOYBNI	(191, 237)	(167, 237)	(167, 253)	(191, 253)
3	36-7	1	SOYBNI	1	SOYBNI	(59, 307)	(81, 307)	(81, 327)	(59, 327)
4	7-23	1	SOYBNI	1	SOYBNI	(135, 773)	(179, 773)	(179, 777)	(135, 777)
5	36-4	2	CORN	2	CORN	(33, 167)	(77, 167)	(77, 177)	(33, 177)
6	36-9	2	CORN	2	CORN	(45, 267)	(61, 267)	(61, 283)	(45, 283)
7	36-8	2	CORN	2	CORN	(21, 319)	(31, 319)	(31, 341)	(21, 341)
8	12-9	2	CORN	2	CORN	(13, 603)	(33, 603)	(33, 625)	(13, 625)
9	6-2	3	OATS	3	OATS	(145, 365)	(185, 365)	(185, 375)	(145, 375)
10	7-1	3	OATS	3	OATS	(135, 591)	(181, 591)	(181, 599)	(135, 599)
11	1-11	3	OATS	3	OATS	(63, 421)	(83, 421)	(83, 455)	(63, 455)
12	6-14	4	WHEAT	4	WHEATS	(177, 471)	(201, 471)	(201, 495)	(177, 495)
13	31-12	4	WHEAT	4	WHEATS	(139, 295)	(175, 295)	(175, 303)	(139, 303)
14	7-2	4	WHEAT	4	WHEATS	(203, 607)	(211, 607)	(211, 665)	(203, 665)
15	12-10	4	WHEAT	4	WHEATS	(17, 656)	(41, 656)	(41, 695)	(17, 695)
16	6-10	5	RDCLI	5	RDCLI	(139, 439)	(183, 439)	(183, 447)	(139, 447)
17		5	RDCLI	5	RDCLI	(69, 599)	(95, 599)	(95, 619)	(69, 619)
18	1-2	5	RDCLI	5	RDCLI	(175, 539)	(195, 539)	(195, 565)	(175, 565)
19	7-24	6	ALFALF	6	ALFALF	(131, 749)	(171, 749)	(171, 755)	(131, 755)
20	7-24	6	ALFALF	6	ALFALF	(129, 731)	(177, 731)	(177, 737)	(129, 737)
21	7-22	6	ALFALF	6	ALFALF	(155, 809)	(183, 809)	(183, 817)	(155, 817)
22	6-8	7	RYE	7	RYE	(127, 527)	(155, 527)	(155, 569)	(127, 569)
23	36-1	8	BRSOIL	8	BRSOIL	(49, 97)	(85, 97)	(85, 115)	(49, 115)

Figure 11-3.— Continued.

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

AUG. 30,1975

APRIORI VALUES INPUT BY CATEGORIES

*** CLASSIFICATION STUDY *** MAPTAP FILE 1

SUBCLASSES CONSIDERED

SYMBOL	SUBCLASS	A PRIORI
1	SOYBNI	.0529
2	CORN	.0529
3	OATS	.0529
4	WHEATS	.6300
5	RDCLI	.0529
6	ALFALF	.0529
7	RYE	.0529
8	BRSOIL	.0529

CHANNELS CONSIDERED

CHANNEL NO.
1
9

Figure 11-3.– Continued.

AUG. 30,1975

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

APRIORI VALUES INPUT BY CATEGORIES

*** CLASSIFICATION STUDY *** MAPTAP FILE 1

```
CLASS    : SOYBNI
SUBCLASS: SOYBNI

MEAN:       169.98    189.99

COVARIANCE MATRIX:
            6.53
            5.55      12.29


CLASS    : CORN
SUBCLASS: CORN

MEAN:       170.86    193.05

COVARIANCE MATRIX:
            9.52
            9.32      8.23


CLASS    : OATS
SUBCLASS: OATS

MEAN:       178.72    183.31

COVARIANCE MATRIX:
            9.12
            3.77      19.99
```

Figure 11-3.– Continued.

AUG. 30,1975

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

APRIORI VALUES INPUT BY CATEGORIES

```
*** CLASSIFICATION STUDY ***   MAPTAP FILE      1

CLASS   : WHEAT
SUBCLASS: WHEATS

MEAN:      179.34    169.66

COVARIANCE MATRIX:

        23.80
        43.77    110.79

CLASS   : RDCLI
SUBCLASS: RDCLI

MEAN:      182.34    199.62

COVARIANCE MATRIX:

        4.30
        2.66      5.73

CLASS   : ALFALF
SUBCLASS: ALFALF

MEAN:      177.83    199.99

COVARIANCE MATRIX:

        3.39
        4.00     11.86
```

Figure 11-3.- Continued.

AUG. 30.1975

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

APRIORI VALUES INPUT BY CATEGORIES

```
***  CLASSIFICATION STUDY  ***   MAPTAP FILE       1


CLASS   : RYE
SUBCLASS: RYE

MEAN:        179.89    168.93

COVARIANCE MATRIX:

            4.92
            4.94     15.13


CLASS   : BRSOIL
SUBCLASS: BRSOIL

MEAN:        169.95    171.54

COVARIANCE MATRIX:

            3.26
             .47      2.17
```


Figure 11-3.– Continued.

```
                    CLASSIFYING FLIGHT LINE C1 DATA
                    EXERCISING ALL OPTIONS EXCEPT B-MATRIX                         AUG. 30,1975
              APRIORI VALUES INPUT BY CATEGORIES

*** CLASSIFICATION STUDY ***    MAPTAP FILE      1


                                             MULTISPECTRAL CHARACTERISTICS FOR
                                                  SOYBNI ( CLASS  1 )
                                                  SOYBNI ( SUBCLASS  1 )

DETERMINANT =                  99.3933
PROB. DENSITY FUNCTION - CONSTANT TERM=    9.7801

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :

        6.5274
         .8506   7.5671

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000


                                             MULTISPECTRAL CHARACTERISTICS FOR
                                                  CORN   ( CLASS  2 )
                                                  CORN   ( SUBCLASS  2 )

DETERMINANT =                  59.6866
PROB. DENSITY FUNCTION - CONSTANT TERM=    9.9699

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :


        9.5185
         .9539   6.2706

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000
```

Figure 11-3.– Continued.

```
                                                                      AUG. 30.1976
                     CLASSIFYING FLIGHT LINE C1 DATA
                     EXERCISING ALL OPTIONS EXCEPT B-MATRIX

               APRIORI VALUES INPUT BY CATEGORIES

 *** CLASSIFICATION STUDY ***   MAPTAP FILE      1

                                MULTISPECTRAL CHARACTERISTICS FOR
                                   OATS    ( CLASS    3 )
                                   OATS    ( SUBCLASS  3 )

DETERMINANT =                163.5095
PROB. DENSITY FUNCTION - CONSTANT TERM=   10.9772

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :

       9.1162
        .9134   17.9356

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000

                                MULTISPECTRAL CHARACTERISTICS FOR
                                   WHEAT   ( CLASS    4 )
                                   WHEATS  ( SUBCLASS  4 )

DETERMINANT =                720.2902
PROB. DENSITY FUNCTION - CONSTANT TERM=    7.5037

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :

       23.7955
        1.8395   30.2700

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000
```

Figure 11-3.— Continued.

AUG. 30,1976

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

APRIORI VALUES INPUT BY CATEGORIES

```
*** CLASSIFICATION STUDY ***   MAPTAP FILE      1

                         MULTISPECTRAL CHARACTERISTICS FOR
                               RDCLI  ( CLASS   5 )
                               RDCLI  ( SUBCLASS  5 )

DETERMINANT =                    17.6743
PROB. DENSITY FUNCTION - CONSTANT TERM=     8.7468

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :

        4.3001
         .6178   4.0870

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000

                         MULTISPECTRAL CHARACTERISTICS FOR
                               ALFALF ( CLASS   6 )
                               ALFALF ( SUBCLASS  6 )

DETERMINANT =                    24.2822
PROB. DENSITY FUNCTION - CONSTANT TERM=     9.0701

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :

        3.3948
        1.1781   7.1527

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000
```

Figure 11-3.– Continued.

```
CLASSIFYING FLIGHT LINE C1 DATA                                    AUG. 30,1975
      EXERCISING ALL OPTIONS EXCEPT B-MATRIX
      APRIORI VALUES INPUT BY CATEGORIES

 *** CLASSIFICATION STUDY ***   MAPTAP FILE       1

                                   MULTISPECTRAL CHARACTERISTICS FOR
                                         RYE    ( CLASS     7 )
                                         RYE    ( SUBCLASS  7 )

DETERMINANT =                    49.9570
PROB. DENSITY FUNCTION - CONSTANT TERM=     9.7915

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :

         4.9166
         1.0049  10.1610

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000

                                   MULTISPECTRAL CHARACTERISTICS FOR
                                         BRSOIL ( CLASS     8 )
                                         BRSOIL ( SUBCLASS  8 )

DETERMINANT =                    6.8311
PROB. DENSITY FUNCTION - CONSTANT TERM=     7.8018

COVARIANCE MATRIX  (CHOLESKY FACTORIZATION) :

         3.2551

** RELATIVE ERROR  ( EUCLIDEAN NORM (K-LDL*)/EUCLIDEAN NORM  K )  =      .00000000
```

Figure 11-3.– Continued.

```
INPUT IMAGE DATA TAPE INFORMATION

    FORMAT                      LARSYS 2
    NO. OF CHANNELS                12
    NO. OF PIXELS/LINE            228
    FIRST SCAN LINE NO.             1
    FIRST PIXEL REFERENCE PT        0
```

Figure 11-3.– Continued.

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

AUG. 30,1975

APRIORI VALUES INPUT BY CATEGORIES

AREA OF CLASSIFICATION

FIELD NAME	NO. OF VERTICES	SAMPLE INC.	LINE INC.	VERTICES
FIELD	4	2	2	(1, 1) (220, 1) (220, 950) (1, 950) (1, 1)

Figure 11-3.— Continued.

CLASSIFYING FLIGHT LINE C1 DATA
EXERCISING ALL OPTIONS EXCEPT B-MATRIX

AUG. 30,1975

APRIORI VALUES INPUT BY CATEGORIES

MAP OF CATEGORY CLASSIFIER CLASSIFICATION RESULTS

CATEGORY NO.	CATEGORY NAME	CLASS NO.	CLASS NAME	SUBCLASS NO.	SUBCLASS NAME	SYMBOL
1	WHEAT	9	WHEAT	9	WHEATS	9
2	NON-WH	1	SOYBNI	1	SOYBNI	1
		2	CORN	2	CORN	2
		3	OATS	3	OATS	3
		5	RDCLI	5	RDCLI	5
		6	ALFALF	6	ALFALF	6
		7	RYE	7	RYE	7
		8	BRSOIL	8	[illegible]	8

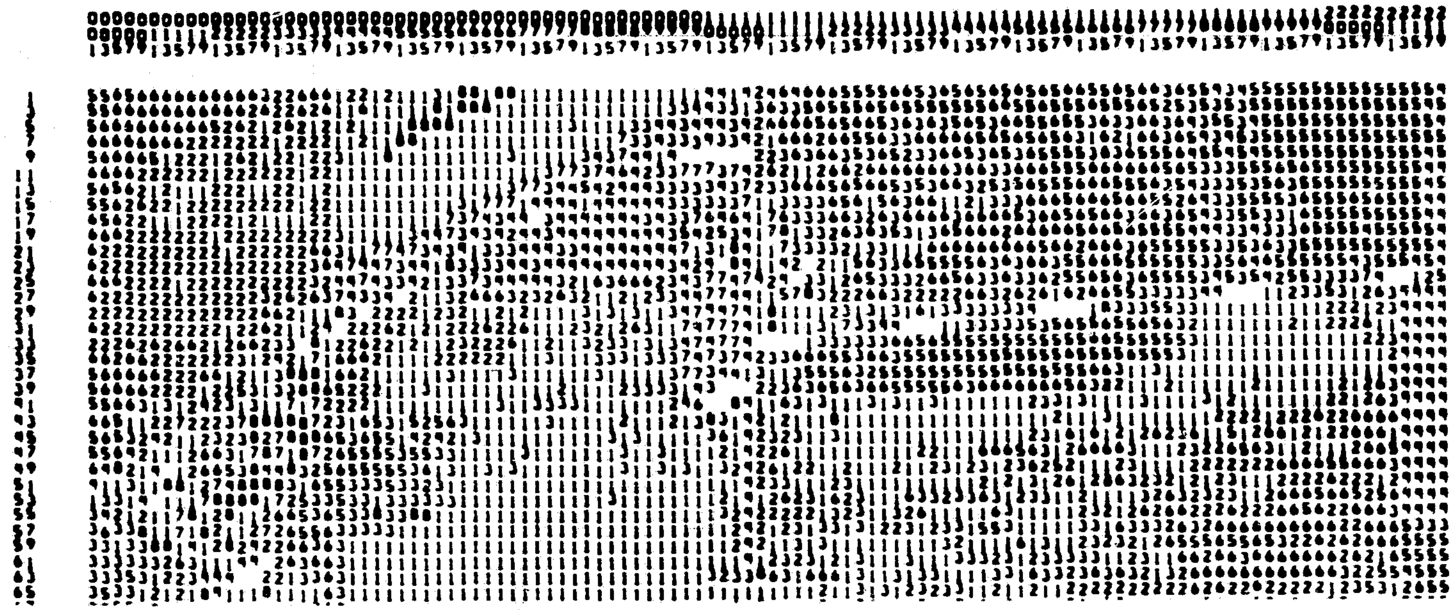


Figure 11-3.— Continued.

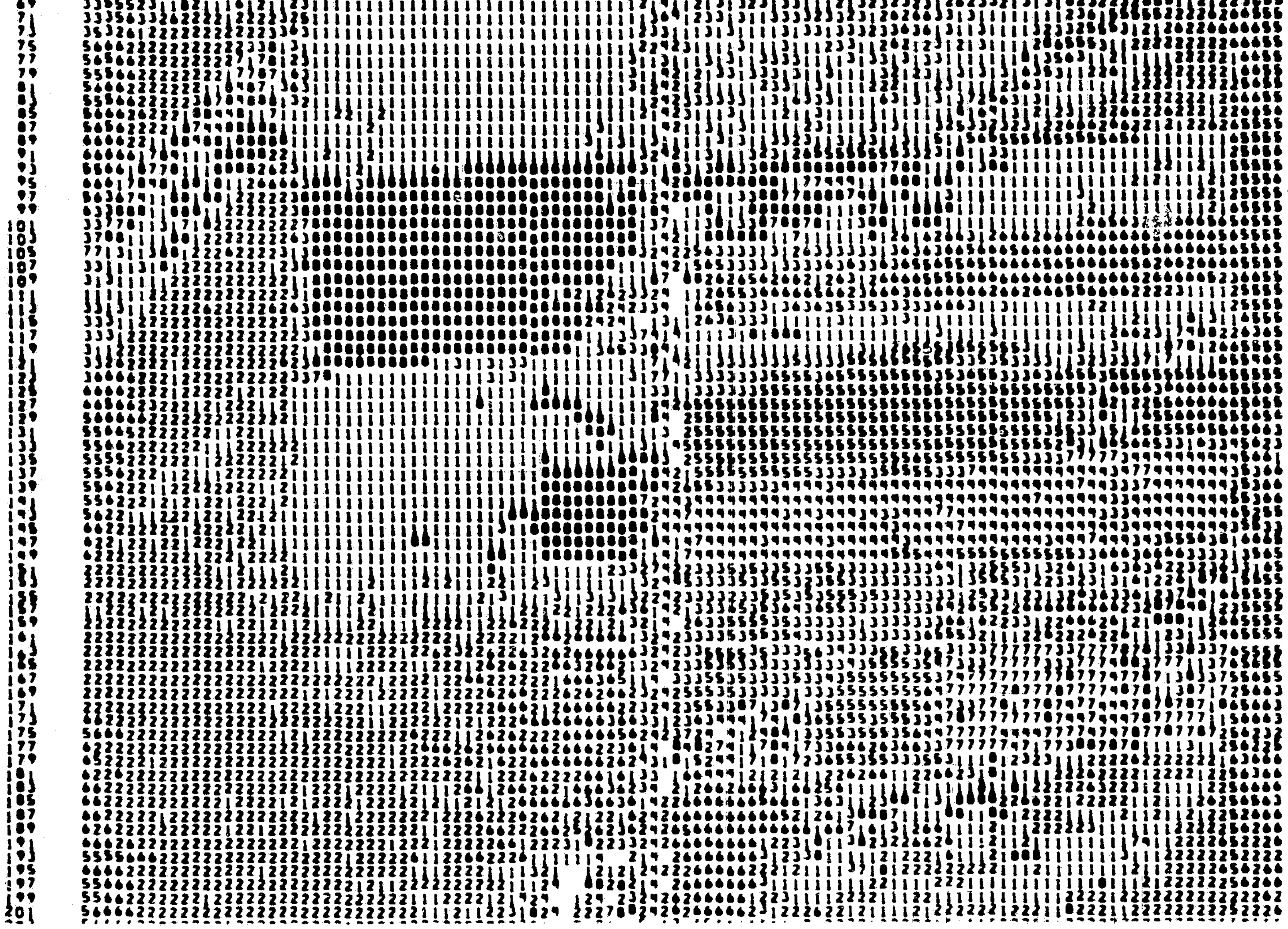


Figure 11-3.– Continued.

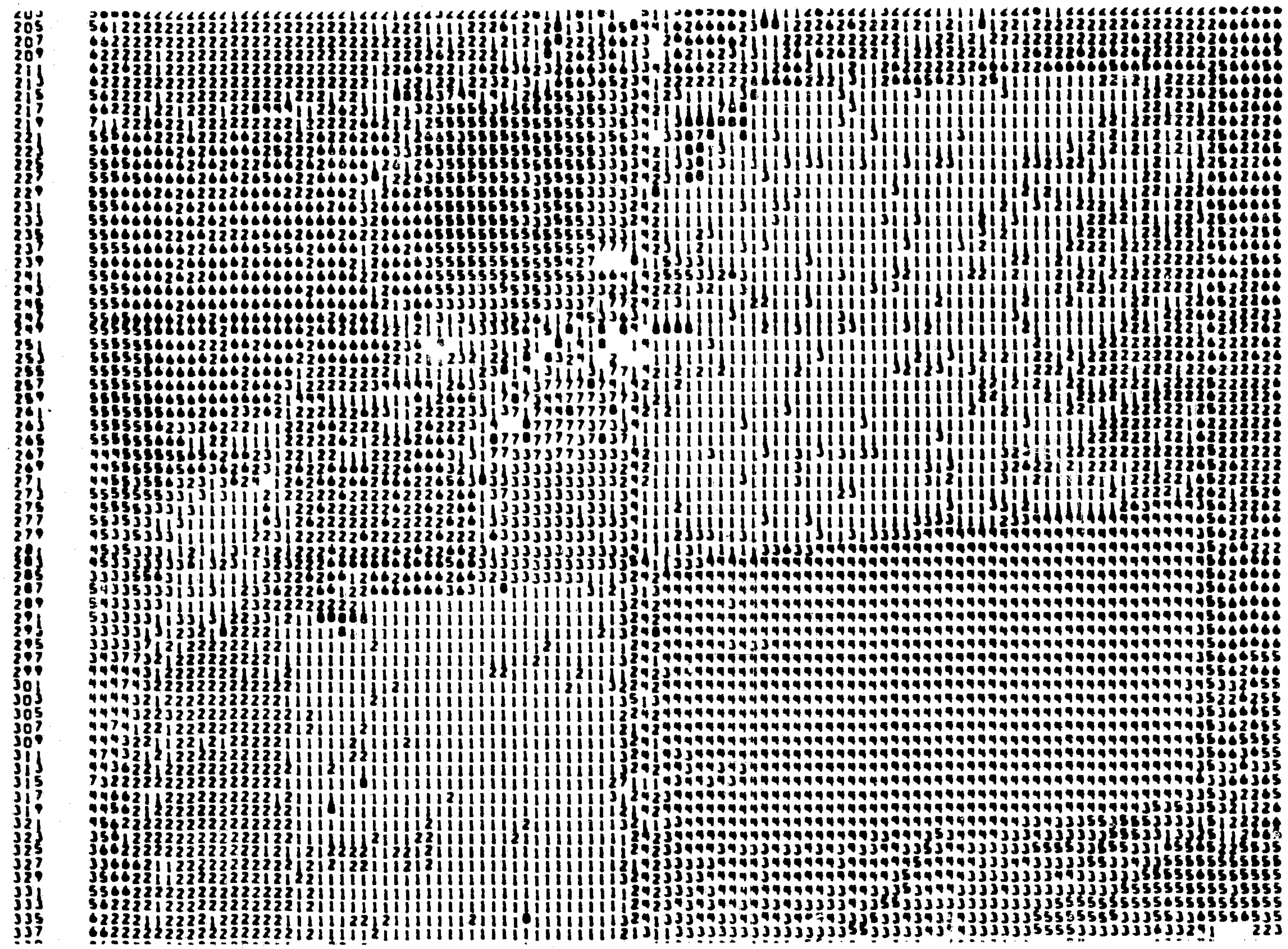


Figure 11-3.– Continued.

ORIGINAL PAGE IS
OF POOR QUALITY

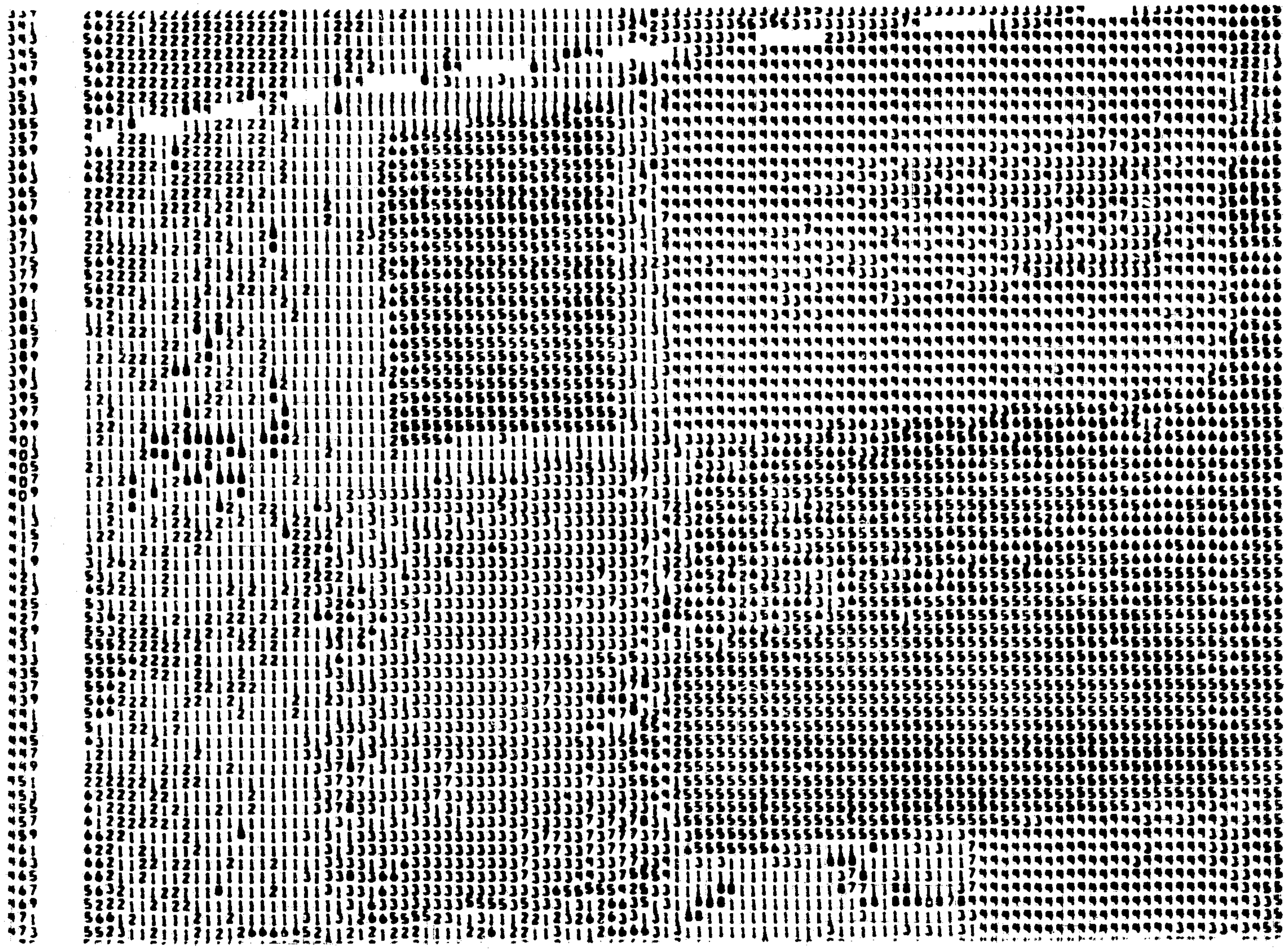


Figure 11-3.- Continued.

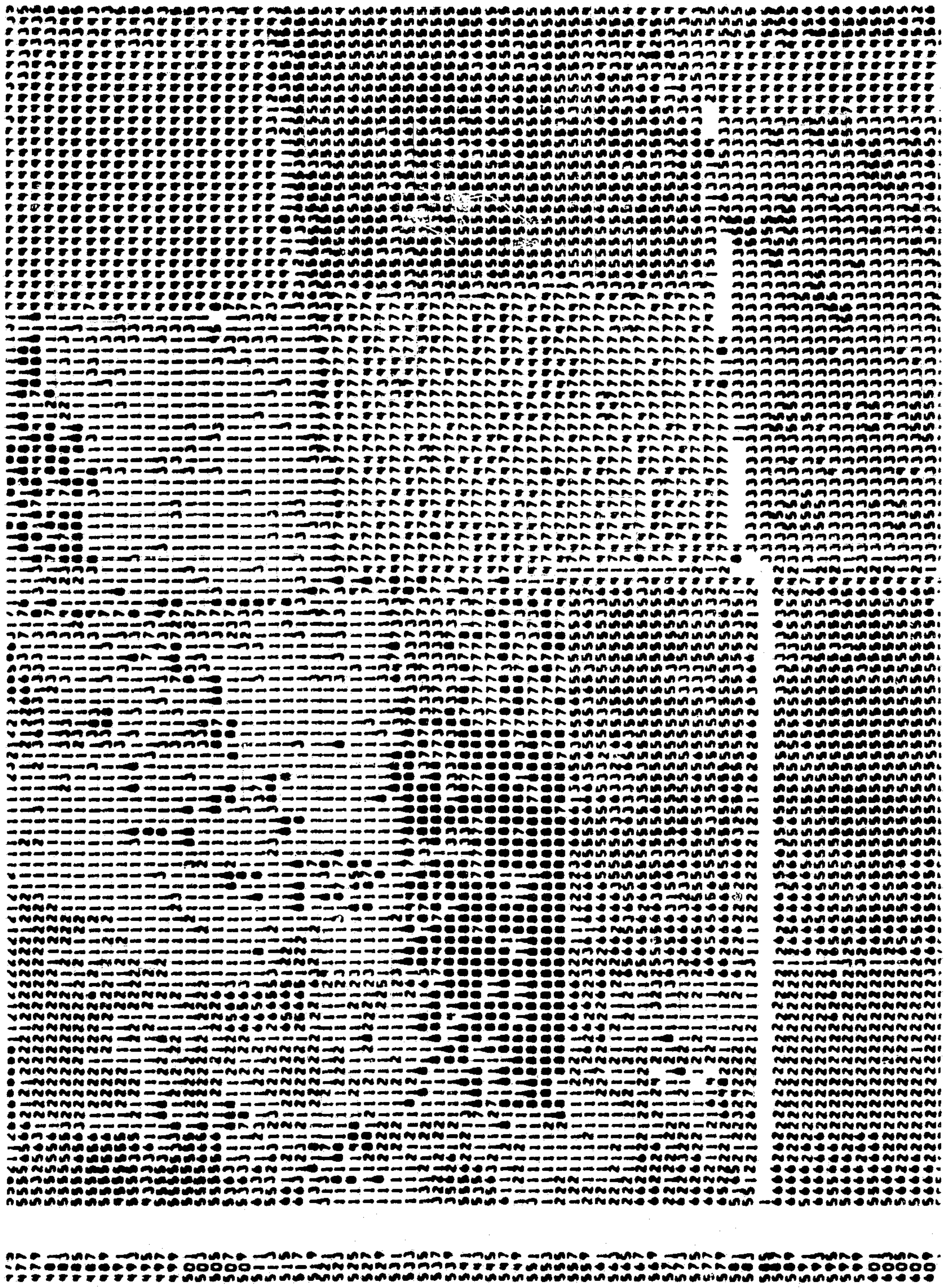


Figure 11-3.- Continued.

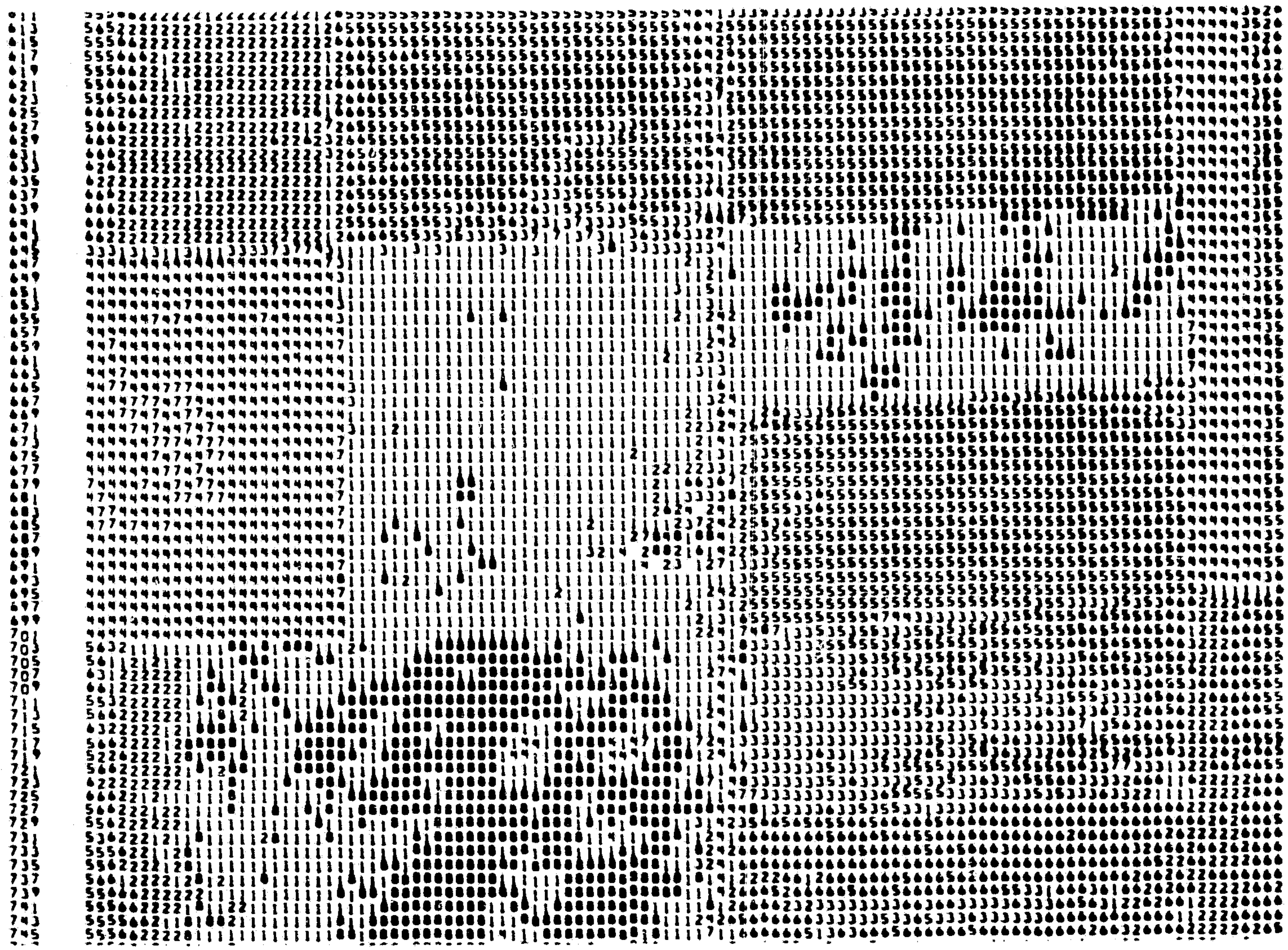


Figure 11-3.— Continued.

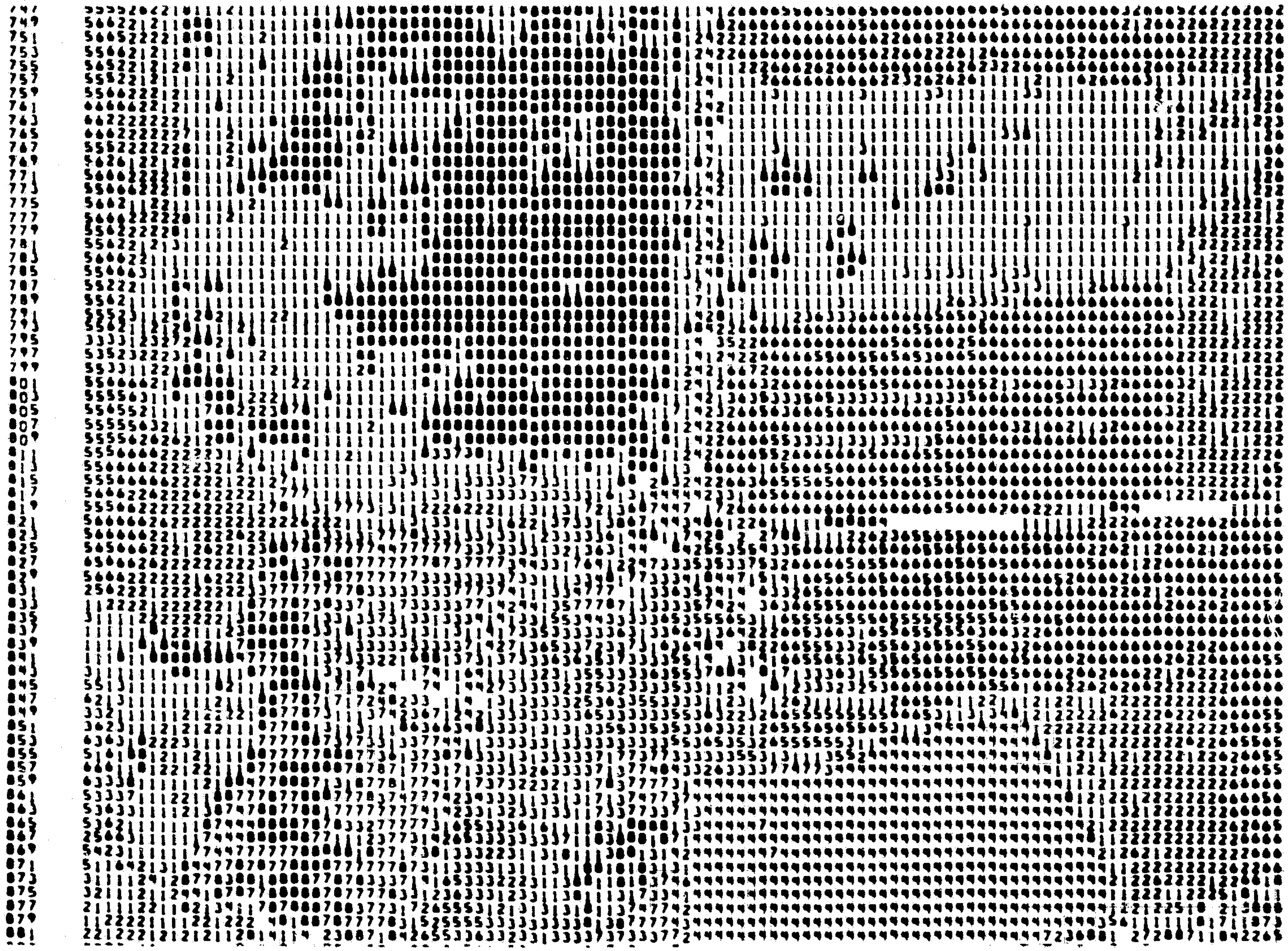
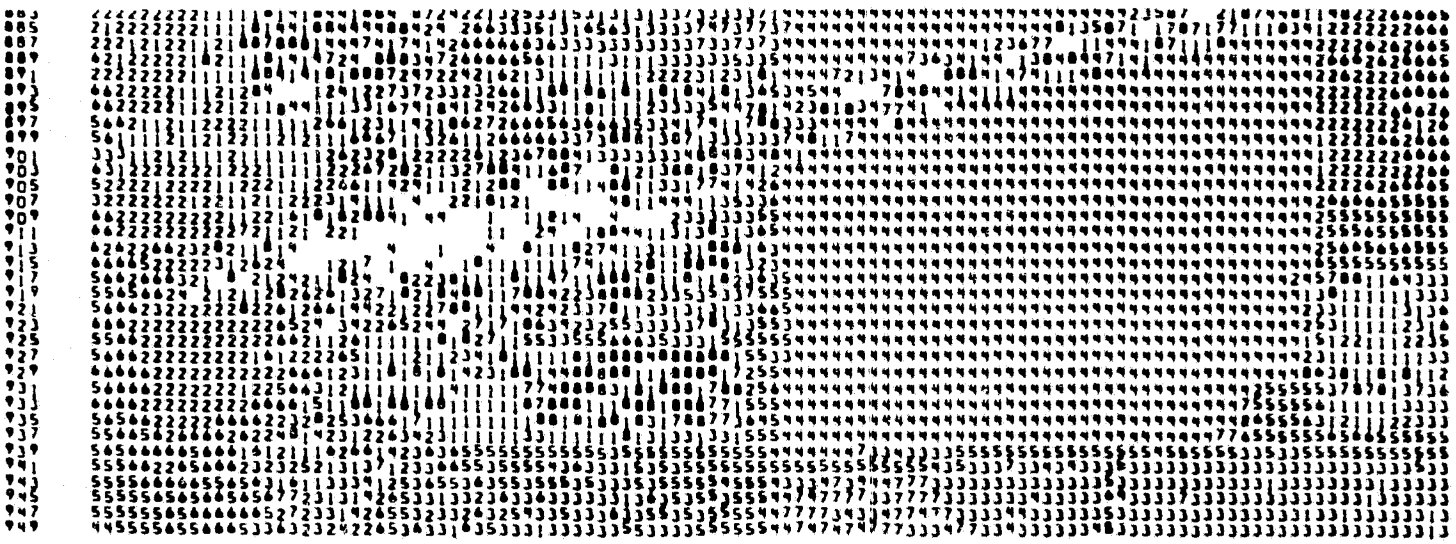


Figure 11-3.- Continued.



AS THE COMPUTER CANNOT EXPONENTIATE A NUMBER SMALLER THAN EXP(-88), 364 PTS WERE NOT CLASSIFIED IN THIS FIELD

*** SCLASSIFY - COMPLETED ***

TIME FOR CLASSIFY 2.106

Figure 11-3.— Concluded.

Card	Sample program listing		Comment/command
1	@Z RUN L78362,TF7,H4,1659,C087,C,15,500	WILLS	EXEC 2 run card
2	@ ASG Z=V10394		Assign EOD-LARSYS program tape
3	@ ASG A=V10680		Assign SAVTAP file
4	@ ASG B=B		Assign a scratch tape for the classification output file
5	@ ASG C=V03662		Assign MSS DATAPE
6	@ XQT CUR		Execute Univac tape complex utility routines
7	TRW Z		Rewind program tape
8	IN Z		Read program tape into system
9	TRI Z		Rewind program tape with interlock
10	@ XCT LARSAA		Execute EOD-LARSYS
11	$CLASSIFY		Execute CLASSIFY processor
12	*END*		End of control card input
13	FIELD (2,1),(1,1),(220,1),(220,100),(1,100)		Define classification field
14	$END*		End of field definition card input
15	$EXIT		Exit EOD-LARSYS
16	@ PMD		Give a core dump if run errs

Figure 11-4.— Sample program listing for the CLASSIFY processor using all default options.

12. PERFORMANCE DISPLAY PROCESSOR – DISPLAY

The DISPLAY processor reads the MAPTAP tape output by CLASSIFY and performs the following functions.

a. Provides a line printer map of each classified field on MAPTAP. The training and test fields within the classified image are outlined.

b. Produces classification summaries for each classified field, which gives a breakdown on the number of pixels classified into, and the number of pixels thresholded from, each subclass, class, and category.

c. Produces (optionally) an intensive test site (ITS) classification summary for one crop type versus all other crop types; the user-specified crop may be a category, class, or subclass.

d. Allows the user to designate fields to be excluded from the classification summaries. Fields may be designated "unidentifiable" or "other." Pixels within the unidentifiable fields are counted and are not considered in the classification summaries. Pixels within the designated "other" fields are counted as a separate crop type regardless of how they were classified. These pixels are included in category "other" in the ITS report. (See section 12.4.4 for sample input of designated fields.)

   All pixels within the designated areas are printed with the pound (#) symbol.

e. Assigns a pixel to the threshold class if thresholding is requested and if $Q_i > t_i$, where

   Q_i = the value of the quadratic form $(X - \mu_i)^T K_i^{-1} (X - \mu_i)$ as computed by CLASSIFY (section 11.1.1) for subclass i

   μ_i = mean vector for subclass i

K_i = covariance matrix for subclass i

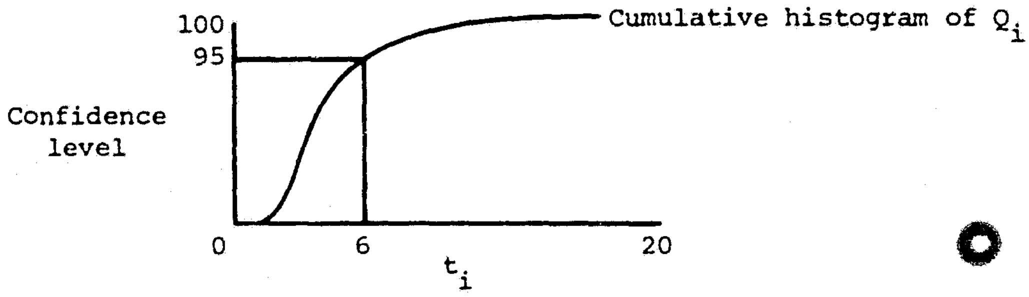
t_i = threshold value for subclass i

f. Allows t_i to be determined in one of four ways:

- User input — The user inputs the exact threshold value. See control cards THRESHOLD and OPTION THRESHOLD VALUE.

- Chi-square option — The user inputs confidence levels for each subclass on the THRESHOLD card and includes the OPTION CHI SQUARE. The program obtains the chi-square threshold value from an internal chi-square functional routine.

- Empirical option — The user inputs confidence levels for each subclass on the THRESHOLD card and includes the OPTION EMPIRICAL card. The program determines the empirical distribution function for each subclass from the cumulative histogram of Q_i for correctly classified pixels in the ground truth areas (i.e., training or test fields), as shown in the following example.



From this curve, the user input of a 95-percent confidence level for subclass i would result in a threshold value of 6.0.

See reference 10 for more information on the use of empirically computed thresholds.

- Fisher F-distribution option — The user inputs confidence levels for each subclass on the THRESHOLD card and includes

the OPTION FISHER card. The program obtains the F-distribution threshold values from an internal routine. If a computational overflow occurs in the routine, the threshold value for that subclass is set equal to 999.999.

g. Produces plots of the empirical distribution function when OPTION PLOT is exercised.

h. Performs (optionally) a four-nearest-neighbors spatial filtering on the classified image. This algorithm takes into consideration that, in many instances, a pixel is most likely to be like its nearest neighbors. When the option is exercised via the OPTION FILTER control card, the four nearest neighbors of each pixel are examined. If all the neighbors are classified the same and the pixel in question is classified differently, then it is assumed that the pixel was classified incorrectly and its classification is changed. In the following example, the pixel classified as X will be changed to C. (See reference 11 for more information on this algorithm.)

Line 1		C	
2	C	X	C
3		C	

i. Outputs (optionally) the classified image onto tape (MAPFIL) in either LARSYS II or Universal format via the FORMAT NAME control card.

j. Provides classification performance summaries for ground truth areas within the classified image. The following six performance summaries are available to the user. The fields in these reports are either training fields used in the STAT or ISOCLS processor and transmitted to DISPLAY via the MAPTAP file or test fields input directly to DISPLAY (see section 12.4.4).

- Field by subclass

- Field by class
- Field by category
- Class by subclass
- Class by class
- Class by category

Figure 12-1 shows the functional flow of the DISPLAY processor.

12.1 INPUT FILES

The only input file required for DISPLAY is the MAPTAP (section 4.4) file output by CLASSIFY. This file must be assigned to logical unit B (Fortran unit 2). If DISPLAY is executed back to back with CLASSIFY, the file may be assigned to Fastrand. However, if DISPLAY is to be executed later, the file must be assigned to tape and saved when CLASSIFY is executed.

12.2 OUTPUT FILES

The DISPLAY processor will optionally generate a MAPFIL tape of the classified image for display on the DAS. The control card FORMAT allows the user to exercise this option. When requested, the tape should be assigned to a nine-track tape drive for compatibility with the DAS tape drives. The tape assignment must be made to logical unit N (Fortran unit 16).

12.3 SCRATCH FILES

The random access drum file is used as a scratch file in DISPLAY. No assignment is necessary.

12.4 CARD INPUT

All system formats referred to in this section are defined in section 3.

12.4.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1; the parameter FILE is punched starting in column 11. For example,

$DISPLAY FILE=N

This card directs the monitor routine to select the DISPLAY processor and initiates the loading of routines used by DISPLAY. Parameter value N is the file number on the MAPTAP file to be processed; if not input, default is to file 1 of MAPTAP.

12.4.2 SPECIAL SYSTEM DECKS

No special decks are required for the DISPLAY processor.

12.4.3 CONTROL CARDS

Table 12-1 lists the control cards and available options for the DISPLAY processor.

12.4.4 CLASS, SUBCLASS, AND FIELD DEFINITIONS

Both test and designated fields are optional input to DISPLAY. However, both types of fields cannot be input in the same execution of DISPLAY. If no test fields are input, the ground-truth summaries will be for training fields. When input, test fields must be identified with a previously defined class or subclass. All test class, subclass, and field definitions begin immediately following the *END* control card and are terminated by the $END* control card. Formats for the CLASSNAME, SUBCLASS, and field definition cards are defined in section 3.1.3. The following example shows test field input to DISPLAY. Note that test fields are identified with classes; that is, each NAME1, NAME2, NAME3, etc., must match the name of a class defined in either STAT or ISOCLS and used in CLASSIFY.

```
$DISPLAY
(Control cards)
*END*
CLASSNAME    NAME1
FIELD1        ---
FIELD2        ---
CLASSNAME    NAME2
FIELD3        ---
FIELD4        ---
FIELD5        ---
CLASSNAME    NAME3
FIELD6        ---
$END*         ---
```

In the following example, test fields are identified with subclasses, in which case each NAME1, NAME2, NAME3, etc., must match the name of a subclass used in CLASSIFY.

```
$DISPLAY
(Control cards)
*END*
SUBCLASS     NAME1
TEST FIELDS  FOR SUBCLASS NAME1
SUBCLASS     NAME2
TEST FIELDS  FOR SUBCLASS NAME2
$END*
```

Designated fields are large areas within the classified area which are either unidentifiable or can be specifically identified as being other than the crop type of interest. This type of field input is meaningful only when the ITS summary report is being generated for one specific crop type. Pixels within unidentifiable areas are removed from the summaries altogether. Pixels within the designated "other" areas are counted as other regardless of how they were classified.

An example of input designated fields follows.

```
$DISPLAY
(Control cards)
*END*
DESIGNATE UNIDENTIFIABLE
(Field definitions)
DESIGNATE OTHER
(Field definitions)
$END*
```

Either one, both, or neither of the two types of designated fields may be input.

12.4.5 DECK SETUP

The deck setup for the DISPLAY processor is given in figure 12-2. The @ in column 1 indicates the master punch for the Univac system, which is the 7-8 multipunch.

12.5 <u>CARD OUTPUT</u>

No cards are output by the DISPLAY processor.

12.6 <u>SAMPLE COMPUTER RUNS</u>

Sample computer program listings are given in figures 12-2, 12-3, and 12-4.

Figure 12-3 illustrates the use of the F-distribution thresholding OPTION FISHER. A map of the classified data on tape X15620 is printed with training fields outlined, a classification summary for each training field classified, and statistics for each classified subclass.

Figure 12-4 is a program listing of DISPLAY using all defaults. It will print a map of classified data on tape V00833, a classification summary for each field classified, and a performance summary by training classes. No thresholding is performed.

Figure 12-5 demonstrates input for generating the ITS summary report and for inputting field designations. The fields were selected to demonstrate the input rather than to show that they were unidentifiable or "other." The crop type CORN was defined as a class in STAT and assigned to the category NONWH in CLASSIFY. Output is provided for this run.

See appendix H for additional output by the DISPLAY processor.

12.7 RESTRICTIONS

The system-related restrictions given in section 5 apply to this processor.

12.8 DIAGNOSTIC MESSAGES

See section 6 for further diagnostic messages.

Message	Explanation
*****DSPLAY/SETUP3 ··· ERROR CONDITION ON ATTEMPT TO POSITION MAPTAP OVER _____ FILES. *****FSBSFL STATUS CODE = _____ --- ABORTING RUN ***	The system routine for positioning files (FSBSFL) has encountered difficulties in positioning MAPTAP to the correct file. Error occurred in SETUP3 routine for DISPLAY. User should make sure that the correct file number for the MAPTAP has been indicated and that MAPTAP does in fact have the correct number of files.
DSPLAY/SETUP3 --- CORE OVERFLOW --- EXECUTION TERMINATED	Subroutine SETUP3 has computed the storage needed for the specific problem; if more is needed than is available, this diagnostic is printed.

Message	Explanation
AA0650 INVALID SUPERVISOR CONTROL CARD.	The invalid card is printed along with this message. Check spelling of the keyword.
WRITE ON UNIT N TERMINATED ABNORMALLY. MAPFIL TAPE NOT CREATED. ISTAT = _____.	Attempt to write on MAPFIL output tape failed. This usually indicates a bad tape. ISTAT is the status code returned from the system binary input/output routine NTRAN. Execution continues.
END OF TAPE ENCOUNTERED ON MAPFIL UNIT. LAST LINE = N.	The end-of-tape marker was encountered on the MAPFIL output tape. The last line written was N. Execution of DISPLAY continues without further attempts to write on the MAPFIL tape.
*****FISHER THRESHOLD REQUESTED - NOT PERFORMED •••NO. SAMPLES FOR SUBCLASS NAME (=N) IS LESS THAN OR EQUAL TO NUMBER OF CHANNELS (=M)	The program compares the number of samples to the number of channels. If the number of samples ≤ number of channels, the threshold request is bypassed.
FDIST-OVERFLOW CONDITION IN FISHIN ROUTINE FOR SUBCLASS=XXXX. THRESHOLD SET TO 999.999	The FISHIN system subroutine has returned an overflow condition. The threshold value is set to 999.999 by the program.

TABLE 12-1.— DISPLAY PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
OPTION	PLOT	Plots the empirical distribution functions obtained from the cumulative histograms of Q_i for each subclass.
OPTION	CHI SQUARE Default:[c]	Computes thresholds from the chi-square distribution using the confidence levels input on the THRESHOLD control card.
OPTION	FISHER Default:[c]	Computes thresholds from the Fisher F-distribution using the confidence levels input on the THRESHOLD control card.
OPTION	EMPIRICAL Default:[c]	Computes the empirical threshold values using the percentages input on the THRESHOLD control card.
		Uses the numbers input on the THRESHOLD control card for the actual threshold value.

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

[c]If the THRESHOLD control card is input, one of the four options (CHI SQUARE, FISHER, EMPIRICAL, or THRESHOLD VALUE) should be input also. If the OPTION card is omitted and the THRESHOLD card is input, chi square is assumed. If more than one THRESHOLD option is input, only the last one read will be performed.

TABLE 12-1.– Continued.

Keyword	Parameter and default values	Function
SYMBOLS	$S_1, S_2, \cdots S_k$ k=number of sub-classes on MAPTAP Default: 1,2,•••9 A,B,C,D,•••,Z, 1,2,3,4	Assigns symbols $S_1, S_2, \cdots$ to subclasses 1,2,•••, respectively.
OPTION	STAT Default: No statistics printed	Prints statistics for sub-classes used in the previous CLASSIFY run. These statistics are saved on the MAPTAP.
OPTION	PCT Default: Performance summary printed for classes only	Prints a performance summary on a per-field as well as a per-class basis for ground-truth fields (i.e., training or test fields within the classified image).
OPTION	OUTLINE Default: Training fields are not outlined.	Outlines training fields with asterisks; has no effect on test fields. (Test fields are always outlined with "+" symbol.)
OPTION	NOMAP Default: Map printed	Instructs the processor not to print a map of the data; only a performance summary is printed.
OPTION	FILTER Default: Spatial filtering is not performed.	Performs four-nearest-neighbors spatial filtering on the classified image.

TABLE 12-1.– Continued.

Keyword	Parameter and default values	Function
THRESHOLD	$T_1,T_2,\cdots T_k$ k=number of subclasses on MAPTAP Default: No thresholding	Uses the threshold values $t_1,t_2,\cdots$ for subclasses 1, 2,···, respectively; thresholds must be positive floating-point numbers. One value must be specified for each subclass on the MAPTAP file. Thresholds may be specified also in the following format: $N_1{*}t_1,N_2{*}t_2,\cdots$ where N_1 and N_2 are integers which specify how many consecutive times the corresponding thresholds should be used. For the CHI SQUARE and the EMPIRICAL options, the numbers input on these cards are the confidence levels (i.e., t_1=0.99 means that the user wants to maintain 99% or reject 1%). The numbers input on the OPTION THRESHOLD VALUE card are the actual values to be used for thresholding (i.e., t_1=10.02 means that the threshold value for subclass 1 is 10.02).

TABLE 12-1.— Continued.

Keyword	Parameter and default values	Function
CROP	NAME Default: No ITS report	Initiates the option for printing the ITS summary report for the crop indicated. NAME must match a category, class, or subclass name used in CLASSIFY.
ACREAGE	TOTAL=X, CROP=Y, OTHER=Z	The total acreage in the ITS is X; acreage of the crop named on the CROP control card is Y; and the acreage of all other crop types in the ITS is Z. X, Y, and Z are floating-point numbers. This input is meaningful only if the CROP control card is input.
SITE	Any 24 characters Default: Blanks	Name of the ITS; used in printing the heading for the ITS summary report.
ANALYST	Any 18 characters Default: Blanks	Name of the data analyst printed in the heading for the ITS summary report.
PROCEDURE	Any 60 characters Default: Blanks	Procedure used in classification of the ITS; printed in the heading for the ITS summary report.

TABLE 12-1.— Concluded.

Keyword	Parameter and default values	Function
FORMAT	NAME Default: No output classification map tape is generated by DISPLAY.	If NAME=UNIVERSAL, the output classification tape (MAPFIL) will be generated in the Universal format. If NAME=LARSYS, the MAPFIL tape will be generated in the LARSYS II format.
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

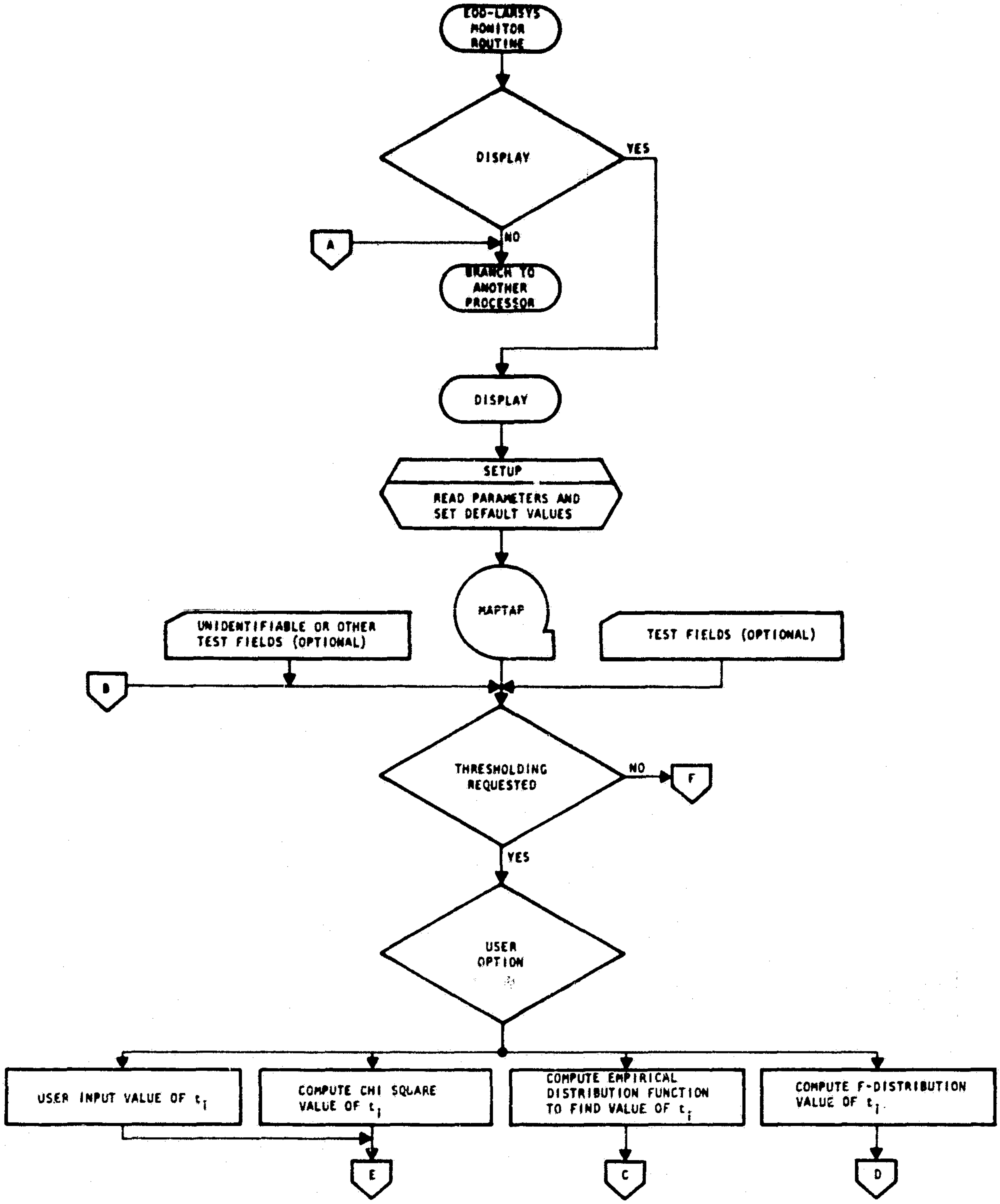


Figure 12-1.– Functional flow chart for the DISPLAY processor.

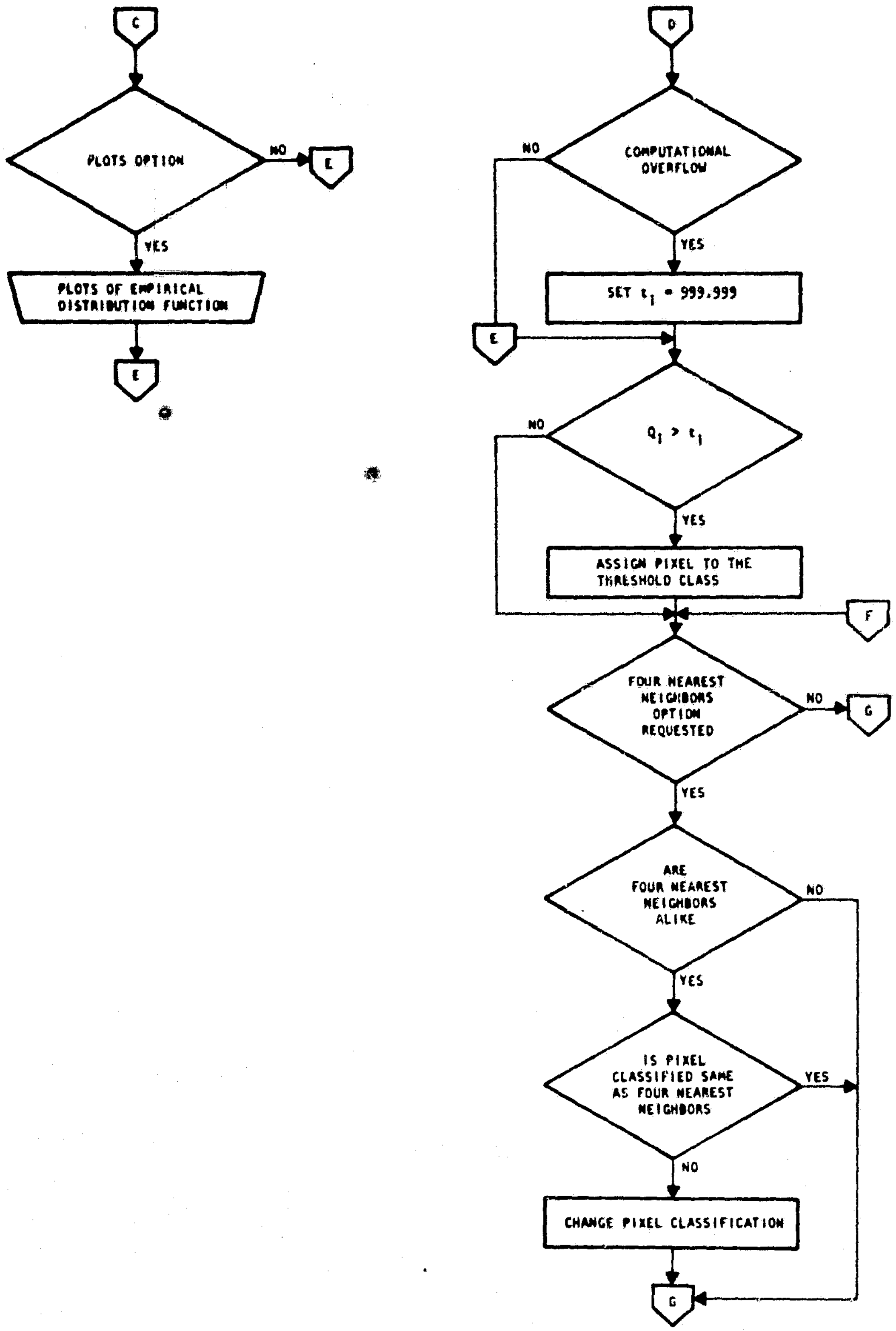


Figure 12-1.– Continued.

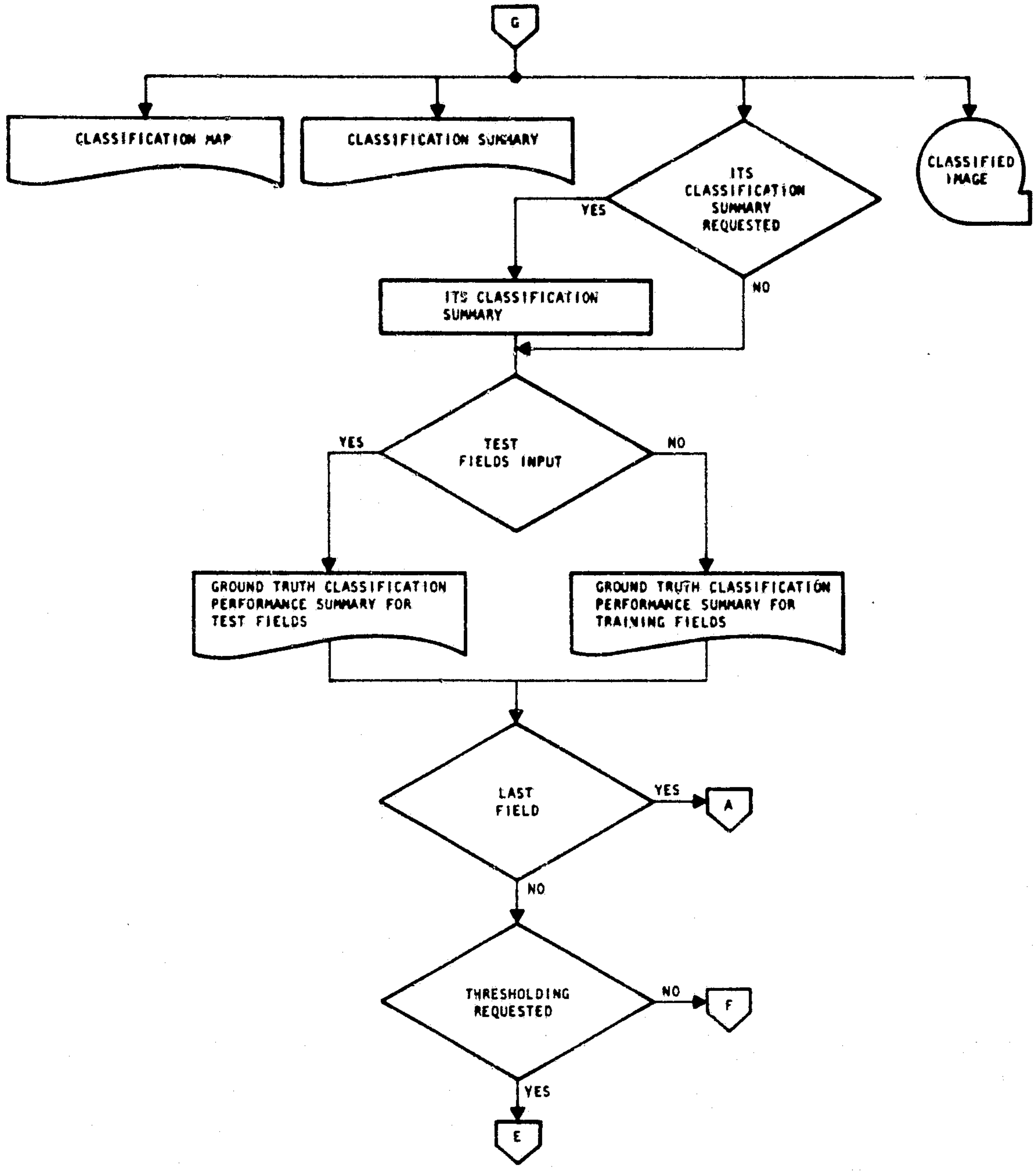
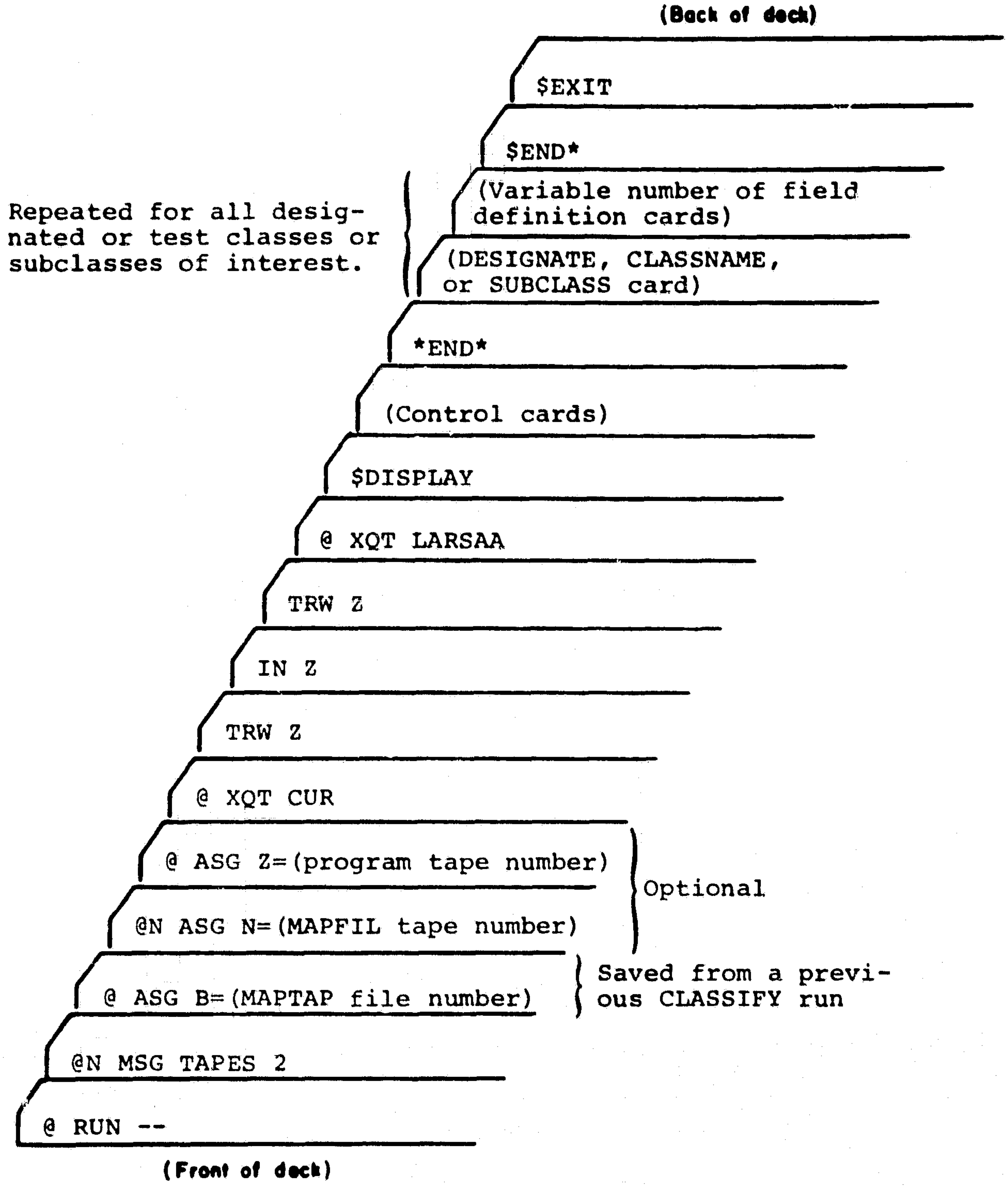


Figure 12-1.– Concluded.



(a) For independent execution.

Figure 12-2.– Deck setup for the DISPLAY processor.

(Back of deck)

```
(Variable number of field
definition cards)
*END*
(Control cards)
$CLASSIFY
@ XQT LARSAA
TRW Z
IN Z
TRW Z
@ XQT CUR
@ ASG Z=(program tape number)
@N ASG N=(MAPFIL tape number)         } Optional
@ ASG C=(MSS DATAPE number)           } May be assigned to
@ ASG B=(MAPTAP file number)          } tape or Fastrand
@ ASG A=(SAVTAP tape number)          } Previously saved
@ RUN --
```

(Front of deck)

(b) For execution back to back with the CLASSIFY processor.

Figure 12-2.– Continued.

(Back of deck)

$END*

(Variable number of field definition cards)

END

(Control cards)

$CLASSIFY

@ XQT LARSAA

TRW Z

IN Z

TRW Z

@ XQT CUR

@ ASG Z=(program tape number)

@N ASG N=(MAPFIL tape number) } Optional

@ ASG C=(MSS DATAPE number)

@ ASG B=(MAPTAP file number)

@ ASG A=(SAVTAP tape number)

@ RUN --

(Front of deck)

Figure 12-2.— Continued.

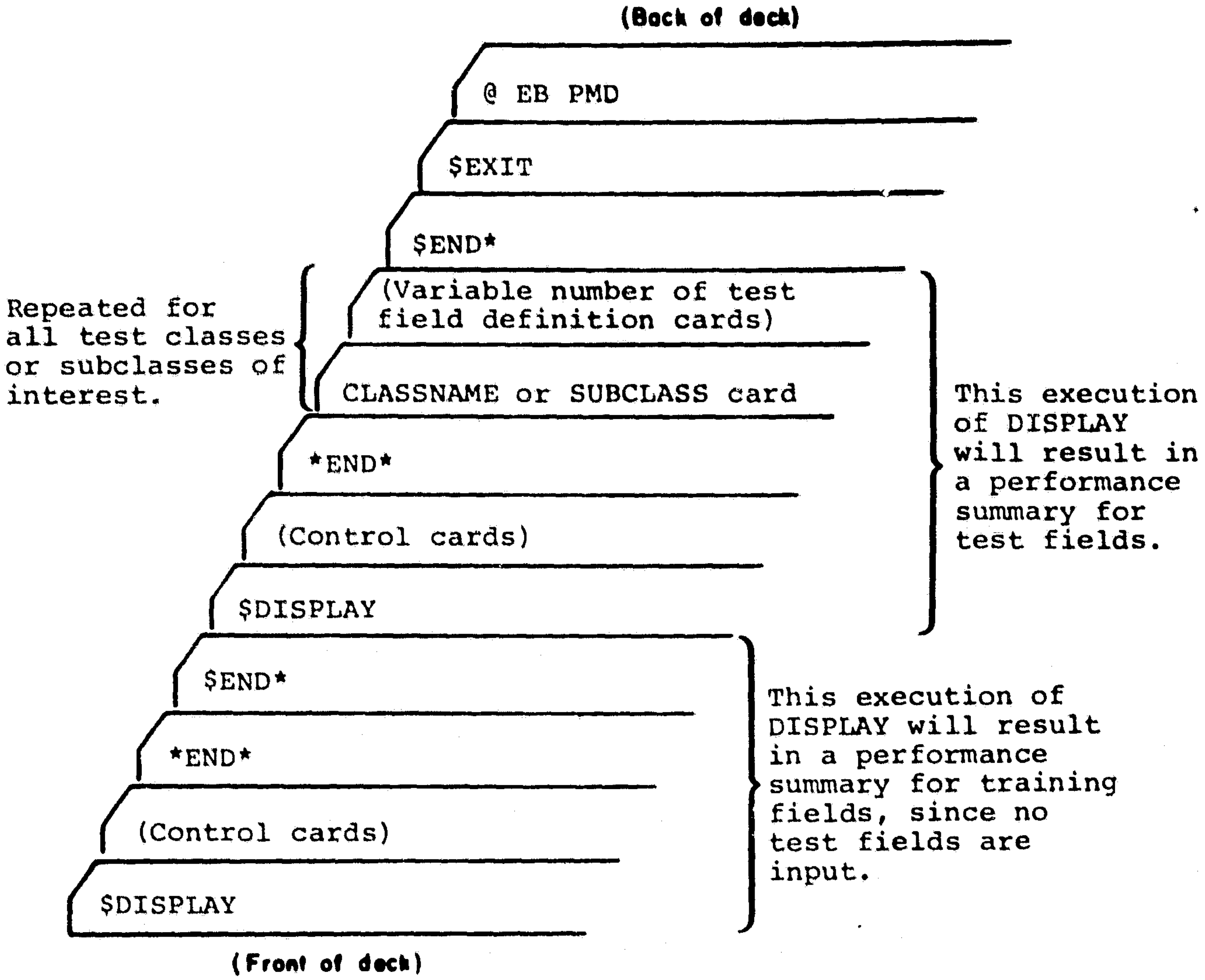


Figure 12-2.– Concluded.

Card	Sample program listing	Comment/command
1	Z RUN L88193,TF3,LXI,1659W,Q619,C,12,5 RODRIGUEZ - LXI	EXEC 2 run card
2	ASG Z=X08942	Assign the EOD-LARSYS program tape
3	ASG B=X15620	Assign a previously saved MAPTAP from CLASSIFY
4	XCT CUR	Execute Univac complex utility routines
5	TRW Z	Rewind program tape
6	IN Z	Read the program tape into the system
7	TRW Z	Rewind program tape
8	XQT LARSAA	Execute EOD-LARSYS program
9	$DISPLAY	Execute DISPLAY processor
10	OPTIONS STATS,PCT,OUTLINE,PLOT,FISHER	OPTIONS[a]
11	THRESHOLD 10*.95	Confidence levels for all 10 subclasses at 95%
12	COMMENT SIMULATED DATA - SS1852	Heading comment input
13	SYMBOLS W,W,B,B,S,S,G,G,F,F	Uses these symbols in the map for each of the 10 subclasses
14	*END*	End of control card input
15	$END*	End of input for this DISPLAY execution
16	$EXIT	Exit LARSYS
17	EAB PMD	Give core dump if run errs, including common areas

[a]STATS – Print statistics.
PCT – Print performance summary by training fields.
OUTLINE – Outline training fields.
PLOT – Plot distribution curves.
FISHER – Perform F-distribution thresholding.

Figure 12-3.– Sample program listing for the DISPLAY processor showing use of F-distribution thresholding.

Card	Sample program listing		Comment/command
1	@Z RUN L73179,TF7,H4,1659,C619,C,3,3	MINTER	EXEC 2 run card
2	@ ASG Z=V14837		Assign the EOD-LARSYS program tape
3	@ ASG H=V00833		Assign a previously saved MAPTAP from CLASSIFY
4	@ XCT CUR		Execute Univac complex utility routines
5	TRW Z		Rewind program tape
6	IN Z		Read program tape into system
7	TRW Z		Rewind program tape
8	@ XCT LARSAA		Execute the EOD-LARSYS program
9	$DISPLAY		Execute the DISPLAY processor
10	*END*		End of control card input
11	$END*		End of all input for this execution of DISPLAY
12	@E PMD		Give core dump if run errs

Figure 12-4.– Sample program listing for the DISPLAY processor using all defaults.

Card	Sample program listing	Comment/command
1	@Z RUN L73179,TF,LXI,1659,C619,C,5,5 MINTER	EXEC 2 run card
2	@ ASG B=V01914	Assign a previously saved MAPTAP from CLASSIFY
3	@ ASG Z=V10498	Assign the EOD-LARSYS program tape
4	@ XCT CUR	Execute Univac complex utility routines
5	TRW Z	Rewind program tape
6	IN Z	Read the program tape into the system
7	TRW Z	Rewind program tape
8	@ XCT LARSAA	Execute the EOD-LARSYS program
9	$DISPLAY	Execute the DISPLAY processor
10	THRESHOLD 99.99	Use a 99% threshold on each of the 9 subclasses
11	ACREAGE TOTAL=596.,CROP=60.,OTHER=53C.	Acreage input for the ITS summary report
12	CROP CORN	The ITS summary report is to be generated for CORN
13	ANALYST MINTER	
14	PROCEDURE ANYTHING GOES	Printed in the heading for the ITS summary report
15	SITE LIKE-C1	
16	*END*	End of control card input
17	DESIGNATE UNIDENTIAFIABLE	Fields following this card are designated unidentifiable
18	DES1 (1,1),(30,100),(50,125),(40,140)	Unidentifiable field
19	DES2 (1,1),(70,200),(90,200),(90,220),(70,220)	Unidentifiable field
20	DESIGNATE OTHER	Fields following this card are designated as other than CORN
21	OTHER1 (1,1),(40,250),(60,260),(65,280),(50,283),(45,270)	Other field
22	OTHER2 (1,1),(125,400),(155,400),(155,430),(125,430)	Other field
23	$END*	End of all input for this execution of DISPLAY
24	@BE PMD	Give core dump if run errs

Figure 12-5.– Sample program listing and output for the DISPLAY processor showing generation of the ITS summary report.

```
LYNDON B. JOHNSON SPACE CENTER                    22 OCT 75
        HOUSTON,TEXAS

$DISPLAY

     THRESH      99.99
     ACREAG      TOTAL=596.,CROP=60.,OTHER=530.
     CROP        CORN
     ANALYS      MINTER
     PROCED      ANYTHING GOES
     SITE        LINE-C1
     *END.


    YOU HAVE SELECTED THE FOLLOWING OPTIONS

        APPLY CHI SQUARE THRESHOLDS
        EXCLUDE PIXELS IN THE DESIGNATED AREAS FROM CLASSIFICATION SUMMARIES
        PRINT THE INTENSIVE TEST SITE SUMMARY REPORT FOR CORN
```

~~12-25~~
308

Figure 12-5.– Continued.

SAVED TRAINING FIELDS

	FIELD		CLASS		SUBCLASS	VERTICES (SAMPLE,LINE)			
1	25-6	1	SOYBN1	1	SOYBN1	(69, 65)	(89, 65)	(89, 81)	(69, 81)
2	31-13	1	SOYBN1	1	SOYBN1	(141, 237)	(167, 237)	(167, 253)	(141, 253)
3	36-7	1	SOYBN1	1	SOYBN1	(59, 307)	(81, 307)	(81, 327)	(59, 327)
4	7-23	1	SOYBN1	1	SOYBN1	(135, 773)	(179, 773)	(179, 777)	(135, 777)
5	36-4	2	CORN	2	CORN	(33, 167)	(77, 167)	(77, 177)	(33, 177)
6	36-9	2	CORN	2	CORN	(45, 267)	(61, 267)	(61, 283)	(45, 283)
7	36-8	2	CORN	2	CORN	(21, 319)	(31, 319)	(31, 341)	(21, 341)
8	12-9	2	CORN	2	CORN	(13, 603)	(33, 603)	(33, 625)	(13, 625)
9	6-2	3	OATS	3	OATS	(145, 365)	(185, 365)	(185, 375)	(145, 375)
10	7-1	3	OATS	3	OATS	(135, 591)	(181, 591)	(181, 599)	(135, 599)
11	1-11	3	OATS	3	OATS	(63, 421)	(83, 421)	(83, 455)	(63, 455)
12	6-14	4	WHEAT	4	WHT 1	(177, 471)	(201, 471)	(201, 495)	(177, 495)
13	31-12	4	WHEAT	4	WHT 1	(134, 295)	(175, 295)	(175, 303)	(134, 303)
14	7-2	4	WHEAT	4	WHT 1	(203, 607)	(211, 607)	(211, 665)	(203, 665)
15	12-10	4	WHEAT	5	WHT 2	(17, 656)	(41, 656)	(41, 695)	(17, 695)
16	6-10	5	RDCL1	6	RDCL1	(139, 439)	(183, 439)	(183, 447)	(139, 447)
17		5	RDCL1	6	RDCL1	(69, 599)	(95, 599)	(95, 619)	(69, 619)
18	1-2	5	RDCL1	6	RDCL1	(175, 539)	(195, 539)	(195, 565)	(175, 565)
19	7-24	6	ALFALF	7	ALFALF	(131, 749)	(171, 749)	(171, 755)	(131, 755)
20	7-24	6	ALFALF	7	ALFALF	(129, 731)	(177, 731)	(177, 737)	(129, 737)
21	7-22	6	ALFALF	7	ALFALF	(155, 809)	(183, 809)	(183, 817)	(155, 817)
22	6-8	7	RYE	8	RYE	(127, 527)	(155, 527)	(155, 569)	(127, 569)
23	36-1	8	BRSOIL	9	BRSOIL	(49, 97)	(85, 97)	(85, 115)	(49, 115)

Figure 12-5.— Continued.

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

22 OCT 75

DESIGNATED FIELDS

FIELD	DESIGNATED	VERTICES (SAMPLE,LINE)
1 DES1	UNIDENTIFIABLE	(30, 100) (50, 125) (90, 190)
2 DES2	UNIDENTIFIABLE	(70, 200) (90, 200) (90, 220) (70, 220)
3 OTHER1	OTHER	(90, 250) (60, 260) (65, 280) (50, 285) (45, 270)
4 OTHER2	OTHER	(125, 400) (155, 400) (155, 430) (125, 430)

Figure 12-5.– Continued.

DISPLAY OF CLASSIFIED FIELD...........F-CU
CLASSIFICATION DATE........13 AUG 75
CLASSIFICATION CHANNELS... 1 6 10 11

MAP OF CATEGORY CLASSIFIER CLASSIFICATION RESULT.

CATEGORY NO.	CATEGORY NAME	CLASS NO.	CLASS NAME	SUBCLASS NO.	SUBCLASS NAME	SYMBOL	THRES.
1	WHEAT	4	WHEAT	4	WHT 1	4	13.277
				5	WHT 2	5	13.277
2	NON-WH	1	SOYBNI	1	SOYBNI	1	13.277
		2	CORN	2	CORN	2	13.277
		3	OATS	3	OATS	3	13.277
		5	RDCLI	6	RDCLI	6	13.277
		6	ALFALF	7	ALFALF	7	13.277
		7	RYE	8	RYE	8	13.277
		8	BRSOIL	9	BRSOIL	9	13.277

** DESIGNATED FIELDS SYMBOL IS *

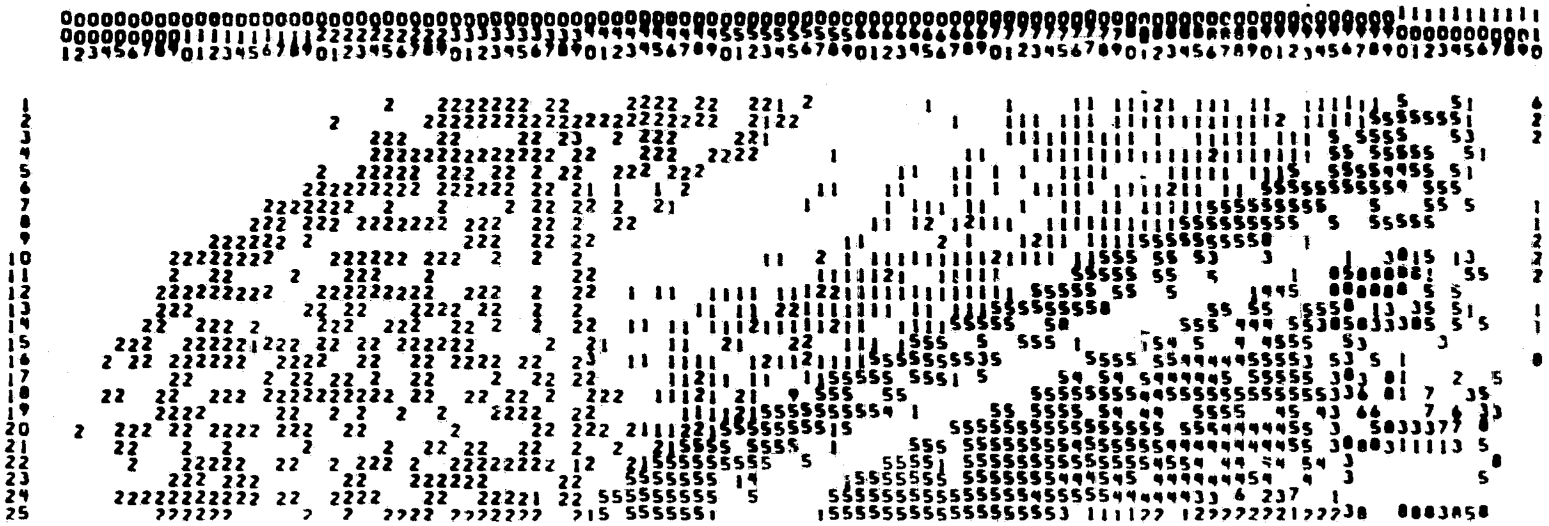


Figure 12-5.– Continued.

Figure 12-5.– Continued.

Figure 12-5.— Continued.

Figure 12-5.- Continued.

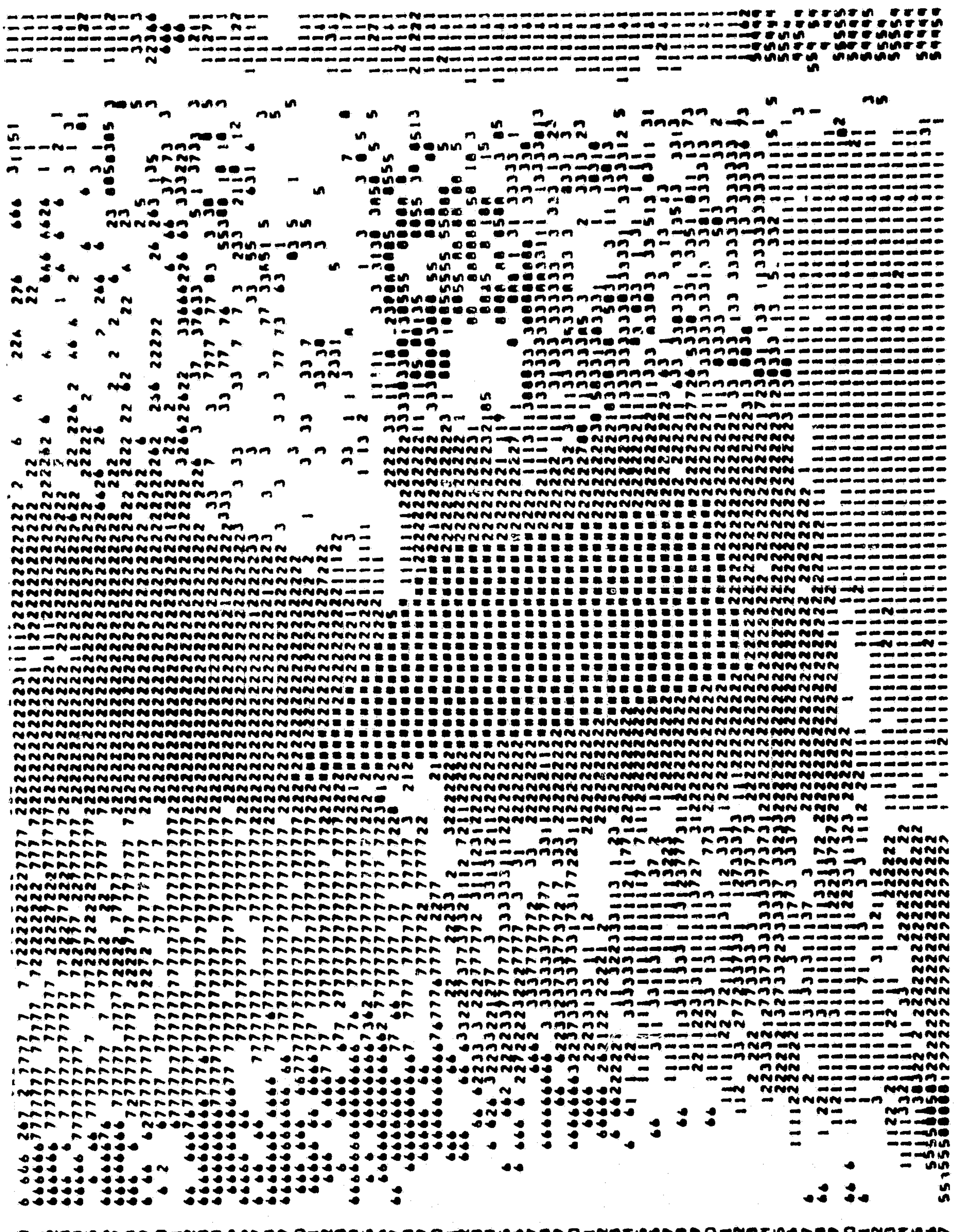


Figure 12-5.- Continued.

LYNDON B. JOHNSON SPACE CENTER 22 OCT 75
HOUSTON, TEXAS

CLASSIFICATION SUMMARY FOR FIELD F-CU

TOTAL NUMBER OF SAMPLED POINTS	209000
LESS DESIGNATED UNIDENTIFIABLE	762

	208238

NO. OF PIXELS DESIGNATED OTHER 1455

SUBCLASS	PTS. BEFORE THRES.	PCT. OF TOTAL CLSF.FLD.	PTS. AFTER THRES.	PCT.OF TOTAL CLSF.FLD.	PCT.OF SUBCLASS	PTS. THRES.	PCT.OF TOTAL CLSF.FLD.	PCT. OF SUBCLASS THRES.
SOYBN1	65165	31.29	42361	20.34	65.01	22804	10.95	39.99
CORN	32666	15.69	23254	11.17	71.19	9412	4.52	28.81
OATS	28582	13.73	17825	8.56	62.36	10757	5.17	37.69
WHT 1	13322	6.40	12545	6.02	94.17	777	.37	5.83
WHT 2	16252	7.80	4715	2.26	29.01	11537	5.54	70.99
RDCL1	26828	12.88	19440	9.34	72.46	7388	3.55	27.59
ALFALF	13560	6.51	10406	5.00	76.74	3154	1.51	23.26
RYE	6364	3.06	4487	2.15	70.51	1877	.90	29.49
BRSOIL	2133	1.02	1771	.85	83.03	362	.17	16.97

PTS. THRESHOLDED IN DISPLAY	68068	
PTS. THRESHOLDED IN CLASSIFY	1911	
TOTAL	69979	PCT. = 33.61

Figure 12-5.— Continued.

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

22 OCT 75

CLASSIFICATION SUMMARY FOR FIELD F-CU

TOTAL NUMBER OF SAMPLED POINTS	209000
LESS DESIGNATED UNIDENTIFIABLE	762

	208238

NO. OF PIXELS DESIGNATED OTHER 1455

CLASS	PTS. BEFORE THRES.	PCT. OF TOTAL CLSF.FLD.	PTS. AFTER THRES.	PCT.OF TOTAL CLSF.FLD.	PCT.OF CLASS	PTS. THRES.	PCT.OF TOTAL CLSF.FLD.	PCT. OF CLASS THRES.
SOYBNI	65165	31.29	42361	20.34	65.01	22804	10.95	34.99
CORN	32666	15.69	23254	11.17	71.19	9412	4.52	28.81
OATS	28582	13.73	17825	8.56	62.36	10757	5.17	37.64
WHEAT	29574	14.20	17260	8.29	58.36	12314	5.91	41.64
RDCLI	26828	12.88	19440	9.34	72.46	7388	3.55	27.54
ALFALF	13560	6.51	10406	5.00	76.74	3154	1.51	23.26
RYE	6364	3.06	4487	2.15	70.51	1877	.90	29.49
BRSOIL	2133	1.02	1771	.85	83.03	362	.17	16.97

PTS. THRESHOLDED IN DISPLAY	68068	
PTS. THRESHOLDED IN CLASSIFY	1911	
TOTAL	69979	PCT. = 33.61

Figure 12-5.– Continued.

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

22 OCT 75

CLASSIFICATION SUMMARY FOR FIELD F-CU

TOTAL NUMBER OF SAMPLED POINTS	209000
LESS DESIGNATED UNIDENTIFIABLE	762

	208238

NO. OF PIXELS DESIGNATED OTHER 1455

CATEGORY	PTS. BEFORE THRES.	PCT. OF TOTAL CLSF.FLD.	PTS. AFTER THRES.	PCT.OF TOTAL CLSF.FLD.	PCT.OF CATEGORY	PTS. THRES.	PCT.OF TOTAL CLSF.FLD.	PCT. OF CATEGORY THRES.
WHEAT	29574	14.20	17260	8.29	58.36	12314	5.91	41.64
NON-WH	175298	84.18	119544	57.41	68.19	55754	26.77	31.81

PTS. THRESHOLDED IN DISPLAY	68068	
PTS. THRESHOLDED IN CLASSIFY	1911	
TOTAL	69979	PCT. = 33.61

Figure 12-5.– Continued.

INTENSIVE TEST SITE SUMMARY REPORT FOR CORN

NAME OF INTENSIVE TEST SITE LINE-C1 NAME OF ANALYST MINTER

PROCEDURE CONFIGURATION ANYTHING GOES

GROUND TRUTH FOR INTENSIVE TEST SITE

ACREAGE OF CORN	A =	60.0
ACREAGE OF OTHER	B =	530.0
TOTAL ACREAGE	C =	596.0

TRUE PROPORTION IN CORN	A/C = D = .101
TRUE PROPORTION IN OTHER	B/C = E = .889

RESULTS OF COMPUTATION FOR INTENSIVE TEST SITE

TOTAL NUMBER OF PIXELS IN INTENSIVE TEST SITE	Y=209000
TOTAL NO. OF PIXELS IN EXCLUSION (UNIDENTIFIABLE) AREA	Z= 762
TOTAL NUMBER OF PIXELS LESS PIXELS IN EXCLUSION AREA	Y-Z=F=208238
NUMBER OF PIXELS CLASSIFIED AS CORN BEFORE THRESHOLDING	G= 32666
NUMBER OF PIXELS CLASSIFIED AS OTHER BEFORE THRESHOLDING	H=173661
NUMBER OF PIXELS CLASSIFIED AS CORN AFTER THRESHOLDING	I= 23254
NUMBER OF PIXELS CLASSIFIED AS OTHER AFTER THRESHOLDING	J=115005
NUMBER OF PIXELS CLASSIFIED AS CORN WHICH WERE THRESHOLDED	G-I=K= 9412
NUMBER OF PIXELS CLASSIFIED AS OTHER WHICH WERE THRESHOLDED	H-J=L= 58656
TOTAL NUMBER OF PIXELS THRESHOLDED	K+L=N= 68068
PROPORTION OF CORN PIXELS THRESHOLDED	K/G=N= .288
PROPORTION OF OTHER PIXELS THRESHOLDED	L/H=O= .338
PROPORTION OF CORN PIXELS THRESHOLDED (OF THE TEST SITE)	K/F=P= .045
PROPORTION OF OTHER PIXELS THRESHOLDED (OF THE TEST SITE)	L/F=Q= .282
PROPORTION OF PIXELS THRESHOLDED	(K+L)/F=R= .327
PROPORTION OF CORN BEFORE THRESHOLDING	G/F=S= .157
PROPORTION OF OTHER BEFORE THRESHOLDING	H/F=T= .834
PROPORTION OF CORN AFTER THRESHOLDING	I/F=U= .112
PROPORTION OF OTHER AFTER THRESHOLDING	J/F=V= .552
PROPORTION OF PIXELS TO BE CONSIDERED AS OTHER	(G+K)/F=W= .879

CROP	NUMBER OF PIXELS	PROPOR. BEFORE THRSH.	COMPUTED PROPOR. LESS TRUE PROPOR. BEFORE THRSH.	NO. OF PX. CLSFY. AFTER THRESHOLD	PROPOR. AFTER THRSH.	PROPOR. THRSH.	COMPUTED PROPOR. LESS TRUE PROPOR. AFTER THRSH.
	(G)	(S)	(S-D)	(I)	(U)	(P)	(U-D)
CORN	32666	.157	.056	23254	.112	.045	.011
	(H)	(T)	(T-E)	(H+K)	(W)	(Q)	(W-E)
OTHER CROPS	173661	.834	-.055	183073	.879	.282	-.010

Figure 12-5.— Continued.

CLASSIFICATION SUMMARY - TRAINING CLASS BY SUBCLASS

CLASS	TOTAL PTS.	PCT. CORCT.	SOYBNI	CORN	OATS	WHT 1	WHT 2	RDCL1	ALFALF	RYE	BRSOIL	THRES
SOYBNI	1524		1485	23	1	0	0	0	0	0	8	7
CORN	1284		23	1240	1	0	0	0	0	0	0	20
OATS	1609		2	0	1530	29	0	24	2	14	0	8
WHEAT	2534		0	0	5	1501	959	0	0	19	0	50
RDCL1	1539		0	1	6	0	0	1487	33	0	0	12
ALFALF	891		0	0	3	0	0	26	859	0	0	3
RYE	1247		0	0	9	0	82	0	0	1143	0	13
BRSOIL	703		0	0	0	0	0	0	0	0	697	6

~~12-37~~
320

Figure 12-5.– Continued.

CLASSIFICATION SUMMARY - TRAINING CLASS BY CLASS

CLASS	TOTAL PTS.	PCT. CORCT.	SOYBNI	CORN	OATS	WHEAT	RDCLI	ALFALF	RYE	BRSOIL	THRES
SOYBNI	1524	97.44	1485	23	1	0	0	0	0	8	7
CORN	1284	96.57	23	1240	1	0	0	0	0	0	20
OATS	1609	95.09	2	0	1530	29	24	2	14	0	8
WHEAT	2534	97.08	0	0	5	2460	0	0	19	0	50
RDCLI	1539	96.62	0	1	6	0	1487	33	0	0	12
ALFALF	891	96.41	0	0	3	0	26	859	0	0	3
RYE	1247	91.66	0	0	9	82	0	0	1143	0	13
BRSOIL	703	99.15	0	0	0	0	0	0	0	697	6

OVERALL PERFORMANCE = 96.25

Figure 12-5.— Continued.

LYNDON B. JOHNSON SPACE CENTER 22 OCT 75
HOUSTON, TEXAS

CLASSIFICATION SUMMARY - TRAINING CLASS BY CATEGORY

CLASS	TOTAL PTS.	PCT. CORCT.	WHEAT	NON-WH	THRES
SOYBNI	1524	99.54	0	1517	7
CORN	1284	98.44	0	1264	20
OATS	1609	97.70	29	1572	8
WHEAT	2534	97.08	2460	24	50
ROCLI	1539	99.22	0	1527	12
ALFALF	891	99.66	0	888	3
RYE	1247	92.38	82	1152	13
BRSOIL	703	99.15	0	697	6

OVERALL PERFORMANCE = 97.90
TIME FOR DISPLAY 1.362

~~12-39~~
322

Figure 12-5.– Concluded.

13. DATA-TRANSFORMATION PROCESSOR – DATA-TR

13.1 PROCEDURES

The DATA-TR processor transforms images from the MSS data tape (DATAPE). The linear transformation is performed on user-defined fields according to the following formula:

$$z = B\bar{x} + b \tag{13-1}$$

where

$k \leq 16$

$n \leq 30$

B = a k-by-n input transformation matrix (see section 3.1.4.2)

$\bar{x}$ = an n-by-1 data vector

b = a k-by-1 bias vector (see BIAS control card, table 13-1)

z = a k-by-1 transformed data vector

The user has the option of rescaling the transformed data via the RESCALE control card. (Control cards are listed in table 13-1.) If no rescaling is performed, it is assumed that the data can be represented in eight bits ($0 \leq z \leq 255$). For rescaling the data to be within the range of 0 to 255, the following equation is computed.

$$Y_i = \frac{255}{R_i} \times |MIN_i - Z_i| \tag{13-2}$$

where

MIN_i = minimum value for component i

Z_i = transformed data point for channel i

R_i = range of component i $[MAX_i - MIN_i]$

MAX_i = maximum value for component i

Y_i = rescaled transformed data point for channel i

The user may obtain the parameters R_i and MIN_i in one of three ways: the histogram method, the statistical method, or user input. The method and control cards associated with each method are defined below.

13.1.1 HISTOGRAM (DEFAULT) METHOD

A histogram of a segment of the transformed image is performed to find the R_i and MIN_i for each component of the transformed data. If the user-defined field is smaller than 2000 pixels, all pixels are used in the histogram; otherwise, the following formula is used to determine the line and sample increments needed to obtain 2000 points for the histogram.

$$\alpha = \left(\frac{MN}{2000}\right)^{1/2} \qquad (13\text{-}3)$$

where

M = number of samples

N = number of lines

α = increment (integer)

In deriving an approximate range for the transformed data, the user may specify a percentage of points to be excluded from the upper and lower tails of the histogram by using the PEROUT control card. If not so specified, 2.5 percent of the points on the tails are excluded when determining the MAX_i and MIN_i values of the central 95 percent of the transformed data distribution.

Optionally, the user may specify the maximum expected data value for each channel n of the input data vector $\overline{x}$. Otherwise, the maximum data value for each channel is set equal to 255.

13.1.2 STATISTICAL METHOD

Activated by the RESCALE and MODULE or STATFILE control card, the statistical method is applied for deriving an approximate MAX_i and MIN_i value for each component i. Using the subclass statistics, an approximate R_i is computed using equations (13-4) and (13-5).

Let $$\alpha_i = MAX_j\left(\hat{\beta}_i^j + k\hat{\sigma}_i^j\right) \qquad (13\text{-}4)$$

and $$\delta_i = MIN_j\left(\hat{\beta}_i^j - k\hat{\sigma}_i^j\right) \qquad (13\text{-}5)$$

where

i = 1,···,m components of Z

j = 1,···,w subclasses

k = an integer specified by the user (see LAM control card)

$\hat{\beta}_i^j$ = transformed mean of the *ith* component of subclass j

$\hat{\sigma}_i^j$ = standard deviation of the *ith* component of subclass j computed from the transformed covariance matrix for subclass j.

The approximate range of each component will be

$$R_i = \alpha_i - \delta_i \quad ; \quad i = 1,\cdots,m \qquad (13\text{-}6)$$

and $$MIN_i = \delta_i \qquad (13\text{-}7)$$

Letting the scale factor $\varepsilon_i = \frac{255}{R_i}$, i = 1,···,m, the complete transformation, including rescaling, to be performed on the original image (each pixel) is:

$$Y_i = \varepsilon_i \times |\delta_i - (B\bar{X} + b_i)| \qquad (13\text{-}8)$$

where

b_i = *ith* element of the bias vector b

Optional control cards that may be used in conjunction with the statistical method are SUBCLA, LAM, PEROUT, OPTION ORIG, and OPTION TRANSF. Their functions, as well as those of other control cards, are described in table 13-1.

13.1.3 USER INPUT METHOD

The user may input his own scaling parameters via the OPTION SCAFAC control card or use input from a previous execution of DATA-TR in which the computed scaling parameters ($255/R_i$,MIN_i) were punched on cards via the OPTION PUNCH control card. When inputting the previously executed deck, the user should note that the values punched were computed using the MIN_i and MAX_i determined after a certain percentage of the tails of the histograms (see PEROUT control card) were discarded.

The transformed/rescaled data are output in either the Universal or LARSYS II format. The option is controlled by the FORMAT control card.

A line printer plot of the histogram (frequency distribution) of the transformed rescaled data is printed. If applicable, the MAX_i and MIN_i are printed.

13.2 INPUT FILES

An MSS data tape (DATAPE) must be input to the DATA-TR processor. The tape assignment defaults to logical unit C (Fortran unit 3); however, by input of the DATAFILE control card, the user may assign any available logical unit. (See table 4-1 for file assignments and section 3.2, MSS Image Data Tapes, for further information on format.)

13.3 OUTPUT FILES

The transformed/rescaled data are output on the TRFORM file, logical unit L (Fortran unit 14), in either the Universal or LARSYS II format.

13.4 SCRATCH FILES

The DATA-TR processor does not use scratch files.

13.5 CARD INPUT

All system card input forms referred to in this section are defined in section 3.

13.5.1 PROCESSOR CARD

The keyword for the processor card is left justified beginning in column 1. For example,

$DATA-TR

This keyword directs the system monitor routine to select the DATA-TR processor and initiates loading of routines used by DATA-TR.

13.5.2 SPECIAL SYSTEM DECKS

The B-matrix deck discussed in section 3.1.4.2 must be input to this processor. The deck may be obtained from a previous execution of SELECT. The module STAT deck (section 3.1.4.1) is optional input. If input, the second method for rescaling the input data (given in section 13.1.2) will be used.

13.5.3 CONTROL CARDS

Table 13-1 lists the control cards and available options for the DATA-TR processor.

13.5.4 FIELD DEFINITIONS

See section 3.1.3 for the format of field definition cards. At least one field definition card must immediately follow the *END* control card. An output file is created for each field definition input and is written on unit L. Each of these fields consists of a rectangular field which surrounds the vertices of the input field. All pixels outside the input field and within the rectangular output field are set equal to zero. The line and sample number will be numbered sequentially from 1.

13.5.5 DECK SETUP

The deck setup for the DATA-TR processor is given in figure 13-1.

13.6 CARD OUTPUT

The DATA-TR processor, via the OPTION PUNCH control card, outputs the computed scaling parameters on cards. Two pairs of scaling parameters are punched on each card; i.e., each punched card contains the scaling parameters for two components of the transformed data. The cards must be used in the same order as punched. Their formats and definitions are as follows. The number of cards is determined by the number of components.

Columns	Type/format	Definition
1–6	A6	OPTION
11–17	A7	SCAFAC=
18–27	A1,F9.3,F9.3,A1	(CON_1,MIN_1) where $CON_1=255/R_1$, R_1 is the range of component 1, and MIN_1=minimum value for component 1. Parentheses must be input.
28–37	A1,F9.3,F9.3,A1	(CON_2,MIN_2) where $CON_2=255/R_2$, R_2 is the range of component 2 and MIN_2= minimum value for

Columns	Type/format	Definition
		component 2. Additional pairs are continued on succeeding cards.

13.7 SAMPLE COMPUTER RUNS

Sample computer runs are given in figures 13-3, 13-4, and 13-5. The first (fig. 13-3) illustrates the situation when no rescaling is performed. Output (not shown) includes a printout of the B-matrix, the definition of the transformed field, and a histogram of the transformed data.

Figure 13-4 illustrates the method of rescaling the transformed data by user input of scaling parameters (OPTION SCAFAC). Figure 13-5 illustrates the method of rescaling the transformed data by the statistical method.

13.8 RESTRICTIONS

The system-related restrictions in section 17 apply to this processor.

The maximum number of channels allowed is 30, and the maximum number of components in the transformed vector is 16.

13.9 DIAGNOSTIC MESSAGES

Message	Explanation
*** BAD SUPERVISOR CONTROL CARD SETUP8 ***	Check spelling of keyword.
*** INVALID CONTROL CARD REJECTED SETUP8 ***	Check spelling of parameter.
*** THE CHANNEL NUMBER MUST LIE BETWEEN 1-30 ***	Incorrect channel number input.

Message	Explanation
*** BAD FIELD CARD FROM LNTRAN ***	Check format of field card.
*** THE NUMBER OF COMPONENTS IN Y-VECTOR TIMES THE NUMBER OF SAMPLES EXCEEDS THE SIZE OF STORAGE AREA - TERMINATE ***.	Self-explanatory.
SETREM ERROR - THERE WERE XX SCALE FACTORS AND MINIMUM VALUES INPUT THROUGH THE SCAFAC OPTION. YY LINEAR COMBINATIONS WERE REQUESTED. THERE MUST BE A SCALE FACTOR AND A MINIMUM VALUE FOR EACH LINEAR COMBINATION. THE PROGRAM WILL TERMINATE THROUGH CMERR.	This message indicates that the input scaling parameter pairs are not in one-to-one correspondence with the number of components of the transformed data. Too many or too few pairs were input.

TABLE 13-1.– DATA-TR PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
B-MATRIX	CARDS or FILE Default: None	CARDS indicates that the B-matrix is on cards immediately following. FILE indicates that the B-matrix is on file and initiates input of the BMFILE.
FORMAT	OUTPUT=UNIVERSAL Default: LARSYS II	The transformed data will be output in Universal format.
FORMAT	OUTPUT=LARSYS Default: LARSYS II	The transformed data will be output in LARSYS II format.
RESCALE	Blanks Default: No rescaling	Initiates rescaling of the transformed data to the range of 0 to 255.
DATAFILE	UNIT=N,FILE=M Default: N=3,M=1	N is the Fortran logical unit number to which the MSS data tape (DATAPE) has been assigned; M is the file number on the tape to be processed.
STATFILE	UNIT=N,FILE=M Default: N=1,M=1	N is the Fortran logical unit number to which the SAVTAP file has been assigned; M is (1) the file number on the tape to be processed or (2), if a module STAT deck is input, the number of the file

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 13-1.– Continued.

Keyword	Parameter and default values	Function
		on which to store the training statistics. If M≠1, this control card must precede the module STAT deck.
OPTION	PUNCH Default: No cards punched	Directs the program to punch the scaling parameters (CON_i,MIN_i) on cards.
OPTION	SCAFAC=(CON_1,MIN_1), (CON_2,MIN_2),···, (CON_i,MIN_i) Default: Histogram method of rescaling	CON and MIN are floating point values separated by a comma. Blanks between the two values are ignored. The scaling parameters should be ordered according to the transformed data vector components.
MODULE	FILE Default: If RESCALE is input, the histogram method is assumed.	Initiates reading of the SAVTAP file; if rescaling is performed, it initiates the statistical method.
MODULE	CARDS Default: If RESCALE is input, the histogram method is assumed.	Initiates reading of the module STAT deck that must immediately follow this card; if rescaling is performed, it initiates the statistical method.
SUBCLASS	S_1,S_2,S_3,···,S_k k≤number of subclasses on SAVTAP≤60	Integers which define a subset of subclasses S_1,S_2,S_3,··· from the input statistics

TABLE 13-1.— Continued.

Keyword	Parameter and default values	Function
	Default: Statistics for all subclasses defined are used in calculating the scaling factors.	(SAVTAP) to be used in calculating the scaling factors and approximating R_i.
LAM	N Default: N=2	An integer multiplied by the standard deviations of the input subclass statistics to derive an approximate range for rescaling the transformed data.
PEROUT	N Default: N=5, in which case 5% of the total distribution will be deleted from both the upper and lower tails of the transformed data set.	An integer which specifies the percentage of points to be deleted from the upper and lower tails of the transformed data distribution in computing an approximate range for rescaling. For the histogram method of rescaling, N/2% is deleted from both the upper and lower tails of the histogram. For the statistical method of rescaling, N% is deleted from both the upper and lower tails of the histogram.
MAXPT	$M_1, M_2, M_3, \cdots, M_k$ $k \leq 30$ Default: 255,255,···	Maximum expected value of MSS data tape (DATAPE) input for each channel. M's are integers

TABLE 13-1.– Continued.

Keyword	Parameter and default values	Function
		used in deriving an approximate range (MIN_i,MAX_i) of the transformed data set for the histogram method of rescaling.
OPTION	ORIG Default: No statistics printout	Initiates the printout of the original (untransformed) statistics for the subclasses input for the statistical rescaling method.
OPTION	TRANSF Default: No statistics printout	Initiates the printout of the transformed statistics.
BIAS	$b_1,b_2,b_3,\cdots,b_k$ or $N{*}b_1,b_{N+1},\cdots,b_k$ k=number of components in the transformed data set and N=an integer repetition factor for b_i $i \leq 16$ Default: b_i=0.0	All b's are decimal (floating point) numbers, separated by commas; they comprise the bias vector to be applied in the transformation of the input data set: $\vec{Z}=B(\vec{x}+b)$
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.

TABLE 13-1.- Concluded.

Keyword	Parameter and default values	Function
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

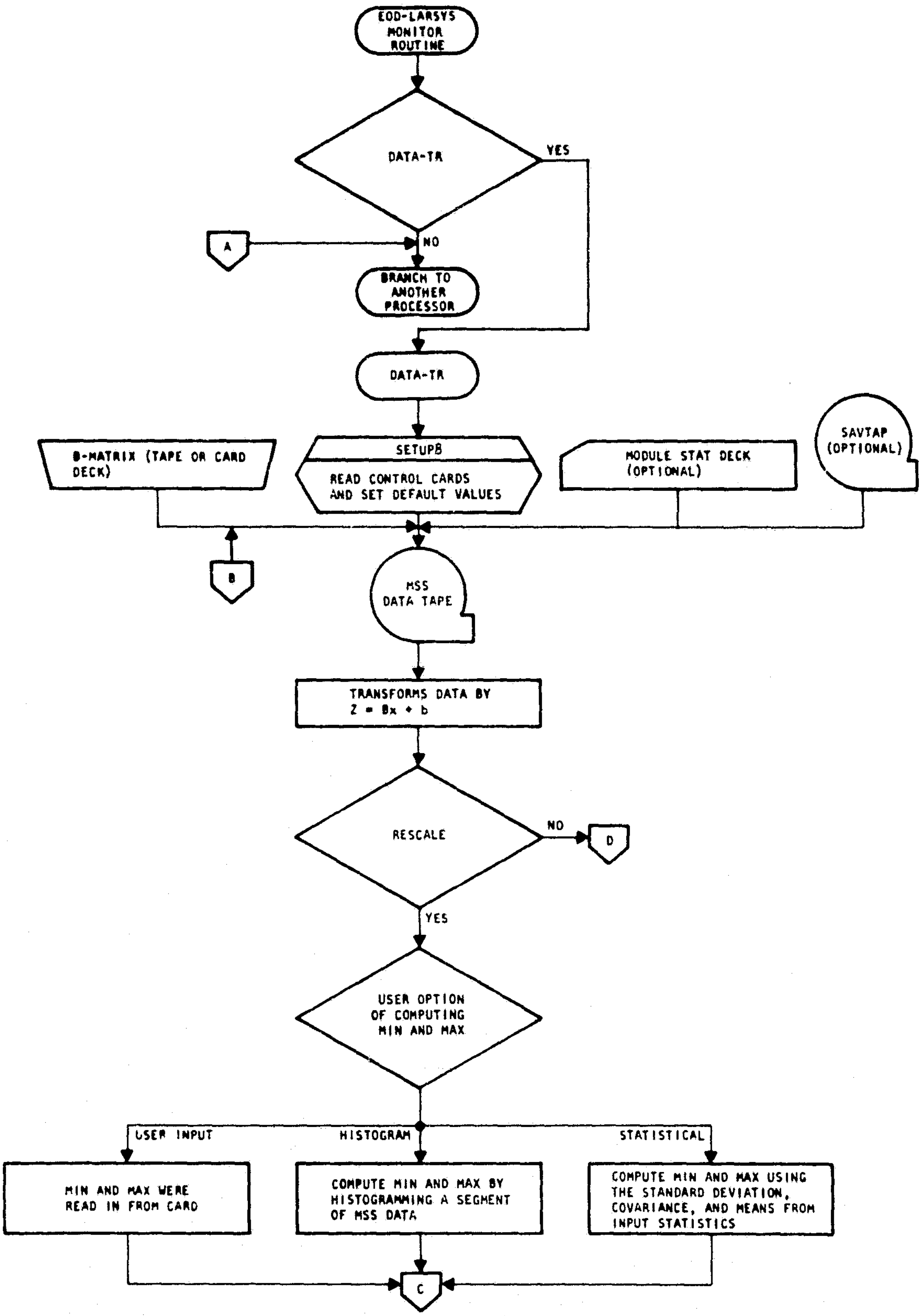


Figure 13-1.– Functional flow chart for the DATA-TR processor.

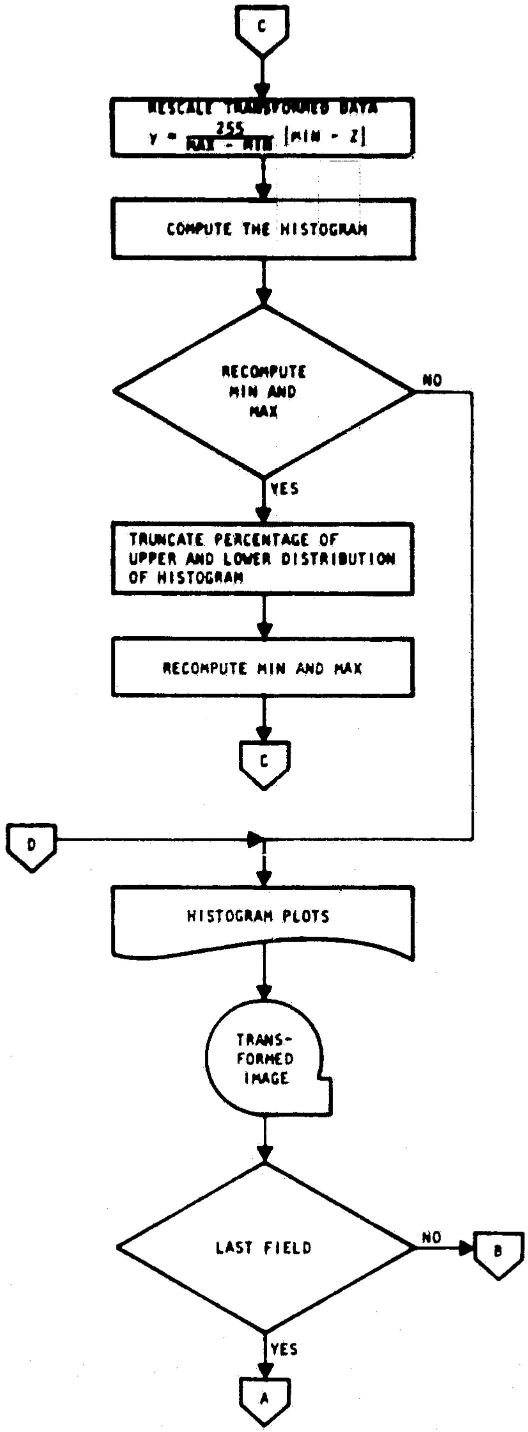
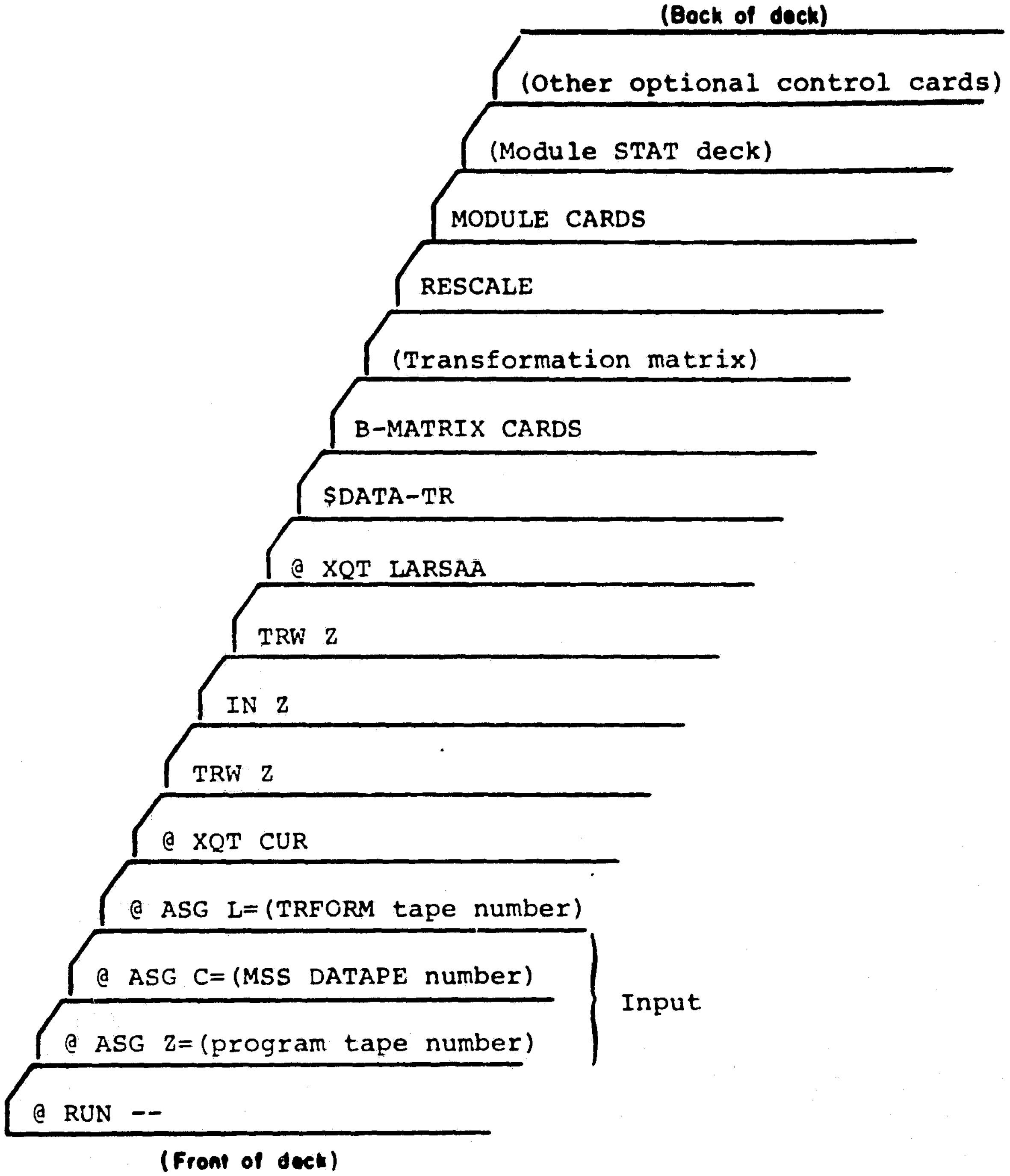


Figure 13-1.— Concluded.



(a) Illustrating card input of rescaling statistics and transformation matrix.

Figure 13-2.– Deck setup for the DATA-TR processor.

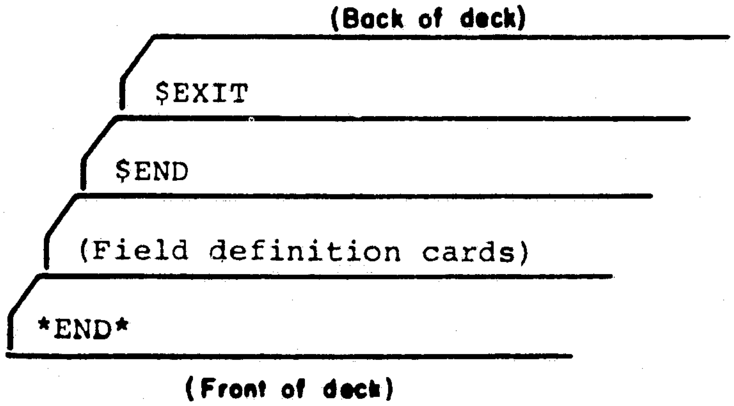
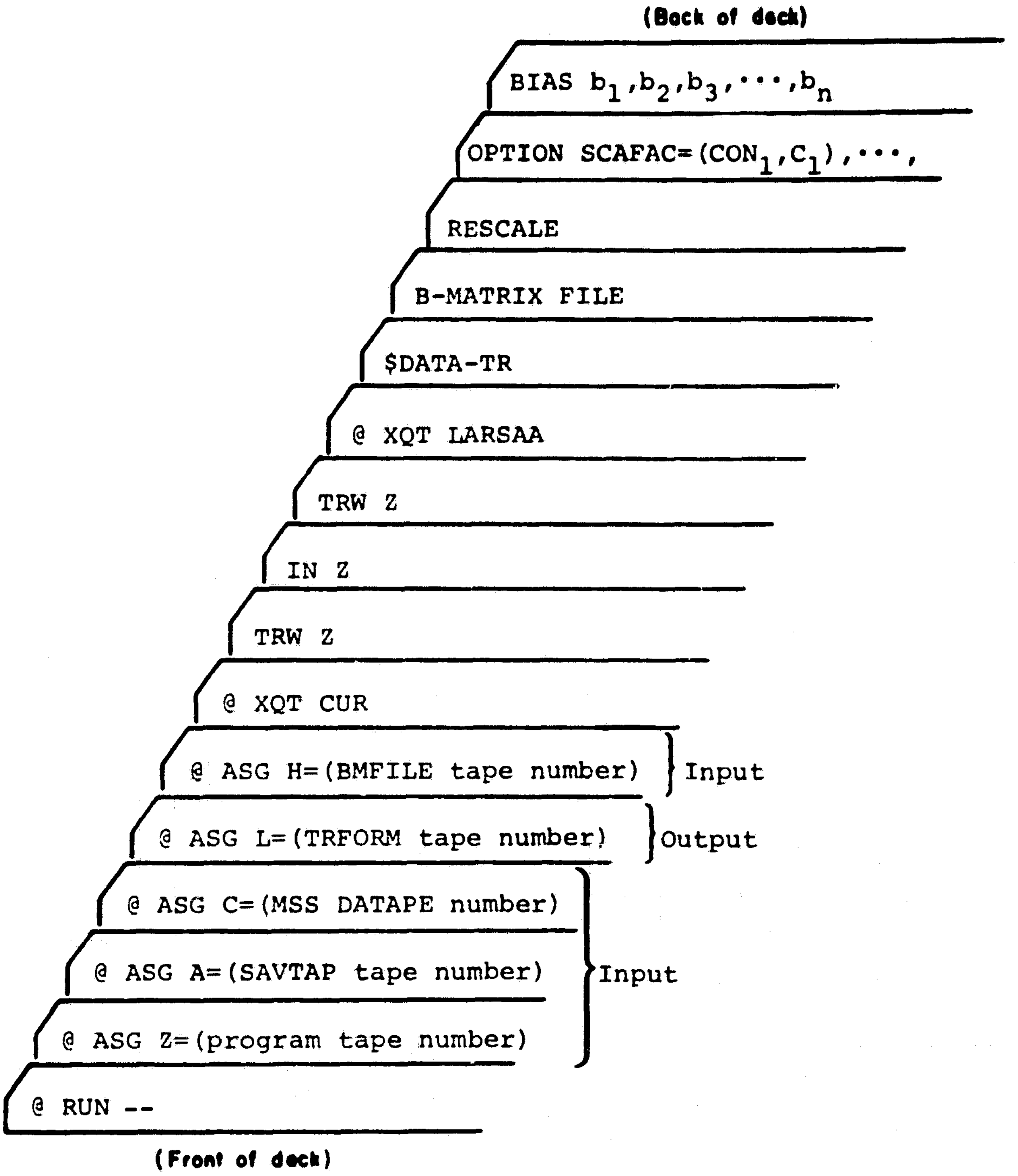


Figure 13-2.— Continued.



(b) Illustrating tape input of transformation matrix, scaling factors, and a transformation bias vector.

Figure 13-2.— Continued.

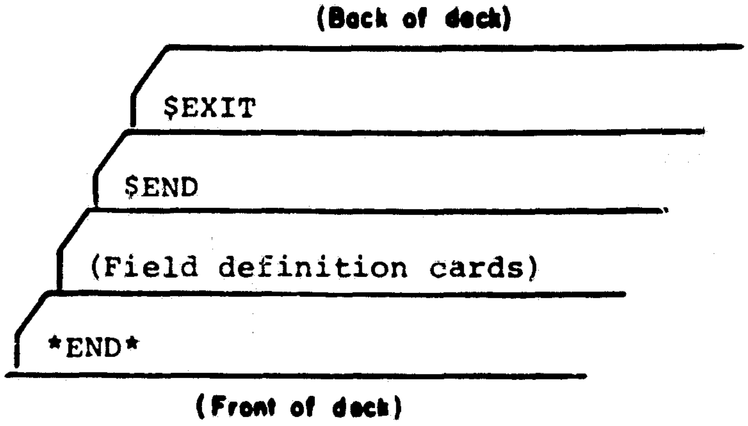


Figure 13-2.– Concluded.

Card	Sample program listing	Comment/command
1	@Z RUN L78388,TF4,H4,1659,C087,C,30,1C CORBETT 2CWB	EXEC 2 run card
2	@N MSG	EXEC 2 message card
3	@ ASG Z=V03795	Assign EOD-LARSYS program tape
4	@ ASG C=V07536	Assign MSS DATAPE
5	@ ASG L	Assign TRFORM file to Fastrand
6	@ XQT CUR	Execute Univac tape complex utility routines
7	TRW Z	Rewind program tape
8	IN Z	Read program tape into system
9	TPW Z	Rewind program tape
10	@ XQT LARSAA	Execute EOD-LARSYS
11	$DATA-TR	Execute DATA-TR processor
12	B-MATRIX CARDS	Read BMFILE from following cards
13	COMB 3FEAT 16VEC 1 2 3 4 9101112171819202526272728	Card type 2 of B-matrix deck
14	BMTRX .5459 +00 -.83 +00 -.3813 +00 -.1888 +00 .6744 -01	
15	.2402 -01 .6024 -01 -.2969 +00 .8715 -01 .2999 +00	
16	.2644 +00 -.1018 +00 .18 +00 -.2633 +00 -.8327 -01	
17	-.5336 +03 .3535 +00 .9172 -01 .1752 +00 -.444 -01	
18	.1011 +00 .9788 +00 .7398 -02 .2381 -01 .1951 -01	B-matrix deck
19	-.179 +00 .1675 +00 -.1461 +00 .3125 +00 -.2304 +00	
20	-.3149 +00 -.8463 -01 .1832 +00 .2657 +00 .4722 +00	
21	-.1911 +00 .2665 +00 .2675 +00 -.2543 +00 .3572 -02	
22	.8947 +00 .8962 -01 -.7238 -01 -.2474 -01 .4354 +00	
23	.1369 +00 .4134 -01 .1031 +01	
24	*END*	End of control card input
25	TR-2 (1,1),(1,1),(40,1),(40,40),(1,40)	Test field definition 1
26	$END*	End of all input for DATA-TR
27	$EXIT	Exit EOD-LARSYS
28	@E PMD	Give a core dump if run errs

Figure 13-3.– Sample program listing for the DATA-TR processor without rescaling.

Card	Sample program listing	Comment/command
1	Z RUN L75321,TF,1659W,C3H7,C,5,5 GARDNER	EXEC 2 run card
2	ASG L	Assign TRFORM to Fastrand
3	ASG C=X23456	Assign MSS DATAPE
4	ASG Z=X22263	Assign EOD-LARSYS program tape
5	XCT CUR	Execute Univac complex utility routine
6	TRW Z	Rewind program tape
7	IN Z	Read program tape into system
8	TRW Z	Rewind program tape
9	XCT LARSAA	Execute EOD-LARSYS
10	$DATA-TR	Execute DATA-TR processor
11	COMMENT ... SAMPLE RUN NO. 4 ...	Heading printout
12	HED1 SAMPLE RUN - DATATR	
13	HED2 FLC1 DATA	
14	B-MATRIX CARDS	Initiates reading of B-matrix
15	COMB 4 4 1 2 3 4	B-matrix deck
16	BMTRX .1 +G1	
17	BMTRX .1 +01	
18	BMTRX .1 +02	
19	BMTRX .1 +C1	
20	RESCALE	Rescale transformed data
21	OPTION SCAFAC= (14.510, 163.340) , (12.448, 165.544)	Input of scaling parameters punched from a previous run; initiates user input method of rescaling
22	OPTION SCAFAC= (17.803, 186.604) , (16.023, 184.725)	
23	PERCUT 5	Percentage of points deleted from tails of the histogram
24	FORMAT OUTPUT=UNIVERSAL	Output TRFORM in the Universal format
25	DATAFILE UNIT=3,FILE=1	Process data in unit C, file 1
26	*END*	End of control card input
27	C-1 (1,1),(1,1),(90,1),(90,90),(1,90)	Field definition of segment to transform
28	$END*	End of card input to DATA-TR
29	$EXIT	Exit EOD-LARSYS
30	E PMC	Give a core dump if run errs

Figure 13-4.– Sample program listing and output for the DATA-TR processor of rescaling by input of the scaling parameters.

```
$DATA=TR

   COMMENT    ... SAMPLE RUN NO. 4 ...
   HED1                          SAMPLE RUN - DATATR
   HED2                           FLC1 DATA
   B-MATRIX  CARDS
   COMB  4       4     1 2 3 4
   BMTRX   .1        .01
   BMTRX   .1        .01
   BMTRX   .1        .01
   BMTRX   .1        .01
   RESCALE
   OPTION     SCAFAC= (   14.510,  163.340 ) ,  (   12.448,  165.544 )
   OPTION     SCAFAC= (   17.803,  186.604 ) ,  (   16.023,  184.725 )
   PEROUT     5
   FORMAT     OUTPUT=UNIVERSAL
   DATAFILE   UNIT=3,FILE=1
   *END*
```

Figure 13-4.– Continued.

... SAMPLE RUN NO. 4 ...

SAMPLE RUN - DATATR
FLC1 DATA

26 APR 77

LINEAR TRANSFORMATION (B) MATRIX

NO. LINEAR COMB. = 4
NO. CHANNELS = 4

LIN. CMB.	CH(1)	CH(2)	CH(3)	CH(4)
1	.1000+01	.0000	.0000	.0000
2	.0000	.1000+01	.0000	.0000
3	.0000	.0000	.1000+01	.0000
4	.0000	.0000	.0000	.1000+01

INPUT IMAGE DATA TAPE INFORMATION

FORMAT	LARSYS 2
NO. OF CHANNELS	12
NO. OF PIXELS/LINE	228
FIRST SCAN LINE NO.	1
FIRST PIXEL REFERENCE PT	1

Figure 13-4.– Continued.

FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)
C-1	4	1	1	(1, 1) (90, 1) (90, 90) (1, 90)

* OUTPUT FILE 1 *

*** TRANSFORMED VALUES RESCALED TO A RANGE 0 - 255 ***
(INPUT SCALING PARAMETERS)

... ORIGINAL TRANSFORMED DATA RANGE ...

MIN	MAX	(BIAS)
103.0000	194.0000	(.0000)
96.0000	211.0000	(.0000)
199.0000	210.0000	(.0000)
196.0000	210.0000	(.0000)

... TRANSFORMED DATA RANGE, AFTER APPLICATION OF PEROUT ...

MIN	MAX	CON = 255/(MAX-MIN)
163.3900	181.5731	13.9855
165.8081	186.5913	12.2743
186.9821	201.6946	17.3600
184.9234	200.6376	16.2258

Figure 13-4.— Continued.

SAMPLE RUN - DATATR
FLCI DATA

25 APR 77

... SAMPLE RUN NO. 9 ...

DATA TR

EACH * REPRESENTS 67 POINT(S).

EACH * REPRESENTS 51 POINT(S).

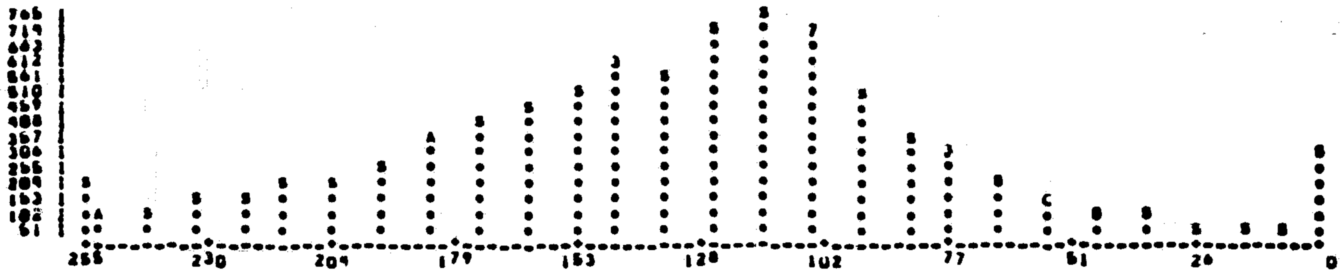


Figure 13-4.– Continued.

SAMPLE RUN - DATATR　　　　　　　　　　　　25 APR 77
FLC1 DATA

... SAMPLE RUN NO. 9 ...

DATA TR

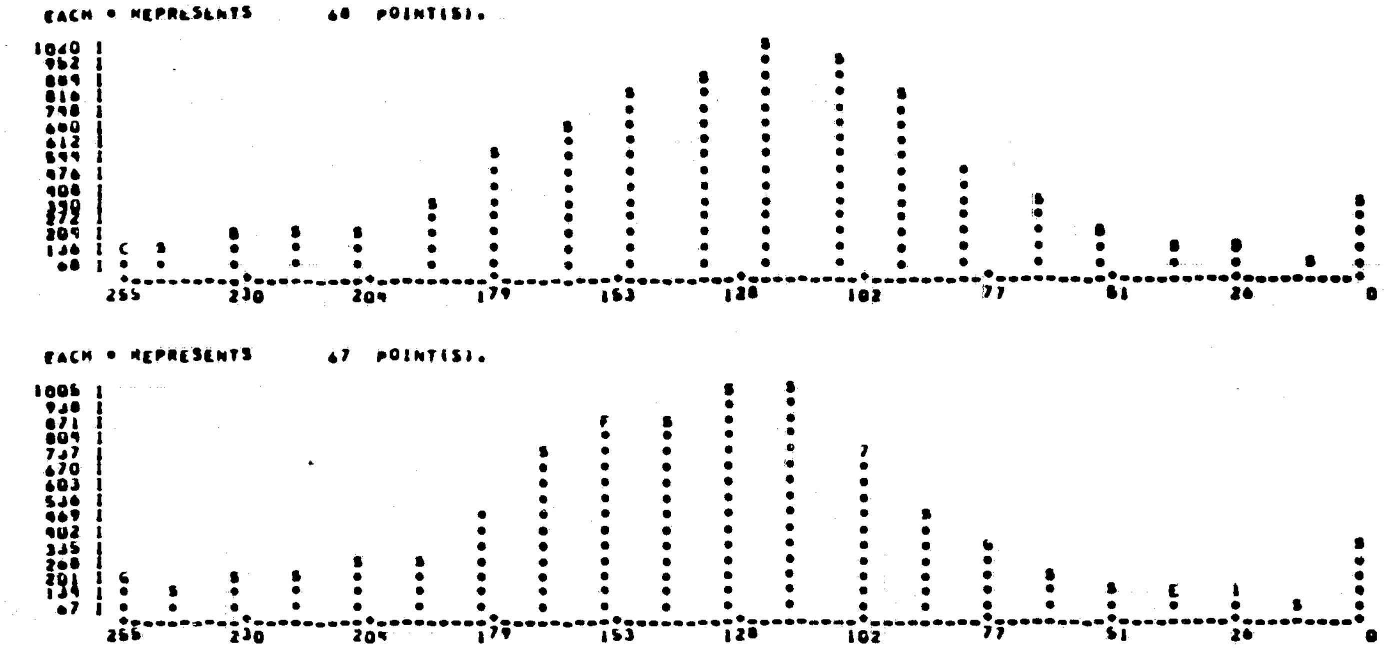


Figure 13-4.- Continued.

SCALING PARAMETERS USED ON TRANSFORMED VALUES, OUTPUT FILE 1

		MINIMUM	MAXIMUM	SCALE FACTOR (CON)
COMPONENT	1	163.340	181.573	13.786
COMPONENT	2	165.880	186.541	12.294
COMPONENT	3	186.962	201.644	17.369
COMPONENT	4	184.924	200.648	16.226

*** SDATA-TN COMPLETED ***

TIME FOR DATA-TRANSFORMATION .085

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Figure 13-4.– Concluded.

Card	Sample program listing	Comment/command
1	Z RUN L75321,TF,1659W,C387,C,5,5 GARDNER	EXEC 2 run card
2	ASG A=X11111	Assign SAVTAP
3	ASG L	Assign TRFORM to Fastrand
4	ASG C=X23456	Assign MSS DATAPE
5	ASG Z=X22263	Assign EOD-LARSYS program tape
6	XCT CUR	Execute Univac complex utitity routine
7	TRW Z	Rewind program tape
8	IN Z	Read program tape into system
9	TRW Z	Rewind program tape
10	XCT LARSAA	Execute EOD-LARSYS
11	$DATA-TR	Execute DATA-TR processor
12	COMMENT ... SAMPLE RUN NO. 2 ...	
13	HED1 DATA TRANSFORMATION PROCESSOR	Heading printout
14	HED2 FL C-1 DATA	
15	DATE JAN 12,1977	
16	B-MATRIX CARDS	Initiates reading of B-matrix
17	CCMB 4 4 1 2 3 4	
18	BMTRX .1 +01	
19	BMTRX .1 +01	B-matrix deck
20	BMTRX .1 +01	
21	BMTRX .1 +01	
22	RESCALE	Rescale transformed data
23	MODULE FILE	Initiate input of SAVTAP
24	SUBCLASS 1,2,3,4,5,6,7,8,9,10,11,12,13	Use these subclasses from SAVTAP in computation of MIN and MAX
25	STATFILE UNIT=1,FILE=1	Initiate input of SAVTAP; process unit A, file 1
26	DATAFILE UNIT=3,FILE=1	Process data in unit C, file 1
27	OPTION ORIG,TRANSF,PUNCH	Print original and transformed statistics; punch scaling parameters
28	LAM 2	Set MIN and MAX ranges
29	PERCUT 5	Percentage of points deleted from tails of histogram
30	BIAS 4*0.0	Additive bias vector is (0.0,0.0,0.0,0.0)
31	FORMAT OUTPUT=UNIVERSAL	Output TRFORM in Universal format
32	*END*	End of control card input
33	FL-C1 (1,1),(1,1),(90,1),(90,90),(1,90)	Field definition of segment to transform
34	*END*	End of card input to DATA-TR
35	$EXIT	Exit program
36	E PMD	Give a core dump if run errs

Figure 13-5.– Sample program listing and output showing rescaled transformed data by the statistical method.

LYNDON B. JOHNSON SPACE CENTER 25 APR 77
HOUSTON, TEXAS

```
$DATA-TR
   COMMENT    ... SAMPLE RUN NO.  2 ...
   HED1              DATA TRANSFORMATION PROCESSOR
   HED2                FL C-1  DATA
   DATE       JAN 12,1977
   B-MATRIX    CARDS
   COMB  4       4      1 2 3 4
   BMTRX    .1        +01
   BMTRX    .1        +01
   BMTRX    .1        +01
   BMTRX    .1        +01
   RESCALE
   MODULE       FILE
   SUBCLASS  1,2,3,4,5,6,7,8,9,10,11,12,13
   STATFILE  UNIT=1,FILE=1
   DATAFILE  UNIT=3,FILE=1
   OPTION     CRIG,TRANSF,PUNCH
   LAM        2
   PEROUT     5
   BIAS       4*0.0
   FORMAT     OUTPUT=UNIVERSAL
   *END*
```

Figure 13-5.– Continued.

DATA TRANSFORMATION PROCESSOR
FL C-1 DATA

JAN 12,1977

... ORIGINAL STATISTICS ...

SUBCLASS 000001

MEAN	165.84	171.16	190.76	189.32
COVARIANCE MATRIX				
	6.56			
	6.40	9.22		
	3.79	3.87	2.94	
	5.30	6.32	3.45	5.64

SUBCLASS 000002

MEAN	172.06	176.99	194.45	193.79
COVARIANCE MATRIX				
	64.91			
	68.67	80.99		
	45.66	50.00	34.29	
	46.76	53.88	34.38	38.64

Figure 13-5.– Continued.

DATA TRANSFORMATION PROCESSOR
FL C-1 DATA

JAN 12,1977

*** ORIGINAL STATISTICS ***

SUBCLASS 000003

MEAN	172.99	177.85	195.47	199.72
COVARIANCE MATRIX				
	6.76			
	4.29	9.18		
	4.05	4.00	4.98	
	3.11	3.99	2.93	4.17

SUBCLASS 000004

MEAN	171.96	175.75	193.34	191.79
COVARIANCE MATRIX				
	172.00			
	145.28	379.47		
	136.12	131.08	113.54	
	80.70	201.04	75.37	137.35

Figure 13-5.- Continued.

DATA TRANSFORMATION PROCESSOR
FL C-1 DATA

JAN 12,1977

... SAMPLE RUN NO. 2 ...

LINEAR TRANSFORMATION (B) MATRIX

NO. LINEAR COMB. = 4
NO. CHANNELS = 4

LIN. CMB.	CH(1)	CH(2)	CH(3)	CH(4)
1	.1000+01	.0000	.0000	.0000
2	.0000	.1000+01	.0000	.0000
3	.0000	.0000	.1000+01	.0000
4	.0000	.0000	.0000	.1000+01

Figure 13-5.– Continued.

DATA TRANSFORMATION PROCESSOR
PL C-1 DATA

JAN 12,1977

... TRANSFORMED STATISTICS ...

SUBCLASS 00BR01

MEAN	165.84	171.16	190.76	189.32
COVARIANCE MATRIX				
	6.56			
	6.40	9.22		
	3.79	3.87	2.94	
	5.30	6.32	3.95	5.69

SUBCLASS 00BR02

MEAN	172.06	176.99	194.95	193.79
COVARIANCE MATRIX				
	64.91			
	68.67	80.99		
	45.66	50.00	34.29	
	46.76	53.88	34.38	38.64

Figure 13-5.– Continued.

```
                                   DATA TRANSFORMATION PROCESSOR                              JAN 12,1977
                                    FL C-1  DATA
             ... TRANSFORMED STATISTICS ...

SUBCLASS #08#03
MEAN          172.99     177.85     195.47     199.72
COVARIANCE MATRIX

               6.76

               4.29       9.18

               4.05       4.00       4.48

               3.11       3.99       2.93       4.17


SUBCLASS #08#04
MEAN          171.96     175.75     193.34     191.79
COVARIANCE MATRIX

             172.00

             145.28     379.47

             136.12     131.08     113.54

              80.70     201.09      75.37     137.35
```

Figure 13-5.– Continued.

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FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)
FL-C1	4	1	1	(1, 1) (90, 1) (90, 90) (1, 90)

* OUTPUT FILE 1 *

*** TRANSFORMED VALUES RESCALED TO A RANGE 0 - 255 ***
(STATISTICS METHOD)

... ORIGINAL TRANSFORMED DATA RANGE ...

MIN	MAX	(BIAS)
103.0000	194.0000	(.0000)
95.0000	211.0000	(.0000)
199.0000	210.0000	(.0000)
196.0000	210.0000	(.0000)

... TRANSFORMED DATA RANGE, AFTER APPLICATION OF PEROUT ...

MIN	MAX	CON = 255/(MAX-MIN)
163.3398	182.9136	14.5103
165.5991	186.0274	12.4980
186.6092	200.7274	17.8033
189.7246	200.6389	16.0239

Figure 13-5.— Continued.

DATA TRANSFORMATION PROCESSOR
FL C-1 DATA

JAN 12,1977

*** SAMPLE RUN NO. 2 ***

DATA TR

EACH * REPRESENTS 67 POINT(S).

EACH * REPRESENTS 51 POINT(S).

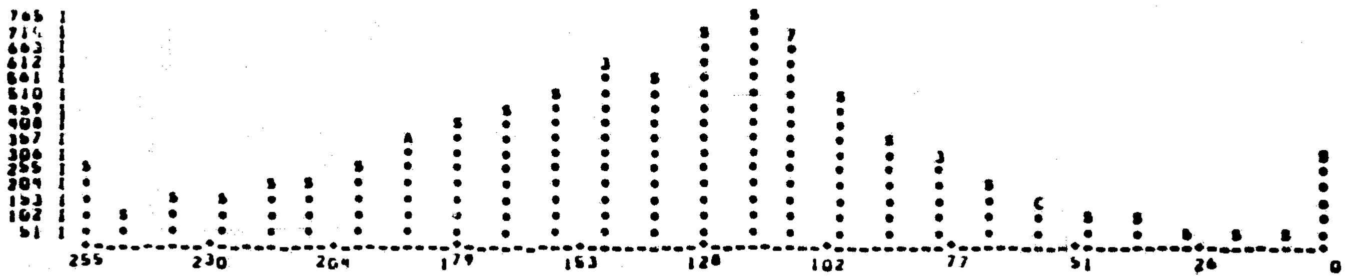


Figure 13-5.— Continued.

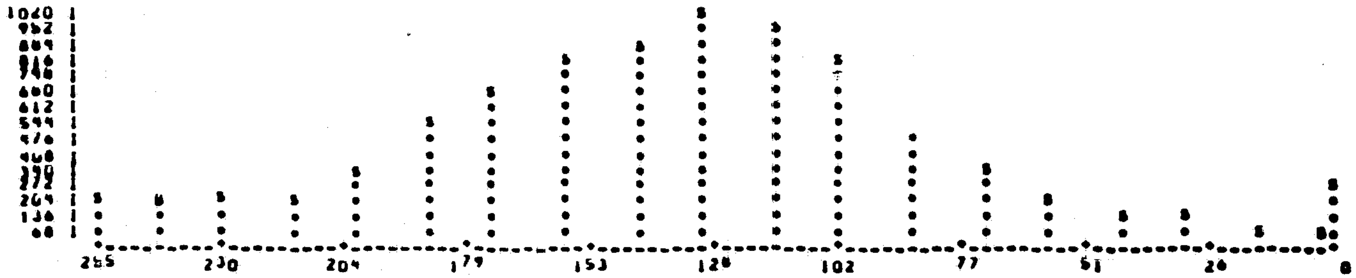
DATA TRANSFORMATION PROCESSOR
FL C-1 DATA

JAN 12,1977

*** SAMPLE RUN NO. 2 ***

DATA TR

EACH * REPRESENTS 68 POINT(S).



EACH * REPRESENTS 67 POINT(S).

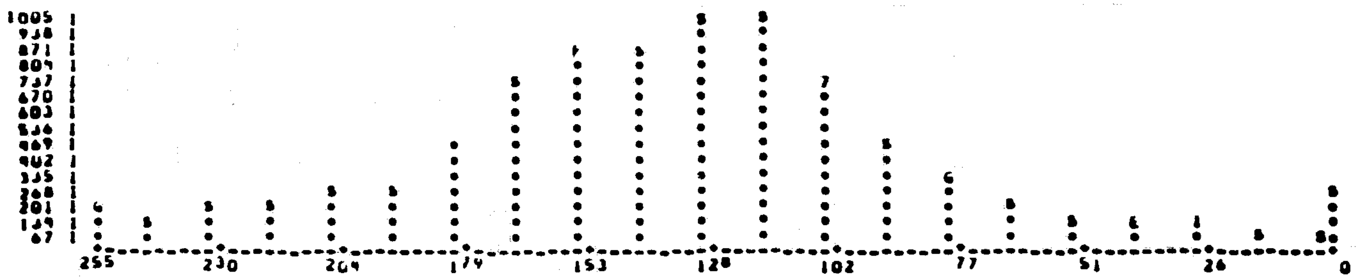


Figure 13-5.— Continued.

SCALING PARAMETERS USED ON TRANSFORMED VALUES. OUTPUT FILE 1

		MINIMUM	MAXIMUM	SCALE FACTOR (CON)
COMPONENT	1	163.340	180.914	14.510
COMPONENT	2	165.544	186.029	12.448
COMPONENT	3	186.604	208.927	17.803
COMPONENT	4	184.725	208.639	16.023

*** $DATA-IN COMPLETED ***

TIME FOR DATA-TRANSFORMATION .981

Figure 13-5.– Concluded.

14. STATISTICS TRANSFORMATION PROCESSOR – TRSTAT

The TRSTAT processor will read a SAVTAP file or card deck generated by STAT or ISOCLS, perform a linear transformation on the means and covariances, and output the transformed statistics on a new file. The equation for the linear transformation of the means is as follows:

$$\mu' = A_{\mu} + b \qquad (14\text{-}1)$$

where

A = a k-by-n matrix (see section 14.4.2); $k \leq 15$ and $n \leq 30$

μ = an n-by-1 mean vector

b = a k-by-1 bias vector (see card type 4, section 14.4.2)

μ' = a k-by-1 transformed mean vector

The equation for the linear transformation of the covariances is as follows:

$$K' = AKA^T \qquad (14\text{-}2)$$

where

K = an n-by-n covariance vector

A^T = an n-by-k transpose of A

K' = a k-by-k transformed covariance matrix

14.1 INPUT FILES

A set of statistics must be input either from the SAVTAP file or by cards. (See STATFILE or MODULE control card, table 14-1.)

14.2 OUTPUT FILES

The transformed statistics are output on a file in the SAVTAP format. (See section 4.1 and STATFILE control card.)

14.3 SCRATCH FILES

The TRSTAT processor uses no scratch files.

14.4 CARD INPUT

All system formats referred to in this section are defined in sections 3 and 14.4.2.

14.4.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$TRSTAT

This card directs the monitor routine to execute the TRSTAT processor and initiates loading of routines used by TRSTAT.

14.4.2 A-MATRIX DECK

The A-matrix deck is composed of a transformation matrix and an additive bias vector. Its format is shown below. For additional information on the transformation matrix, see section 3.1.4.2.

Card type	Columns	Type/format	Definition
1	1–8	Alphanumeric	Keyword A-MATRIX.
2	6–7	Integer/I2	Number of linear combinations.
	13–14	Integer/I2	Number of channels.
	17–80	Integer/I2	Actual channels used in computation.[a]
3	6–20	Real/E15.8	Element 1
	21–35	Real/E15.8	Element 2
	⋮		⋮
	66–80	Real/E15.8	Element 5 of A-matrix – the full matrix is punched,

[a]The channels in the B-matrix described in section 3.1.4.2 begin in column 18.

Card type	Columns	Type/format	Definition
			5 values per card. Additional elements are continued on succeeding cards.
4	6–20	Real/E15.8	Element 1[a]
	21–35	Real/E15.8	Element 2
	⋮		⋮
	66–80	Real/E15.8	Element N of b-vector, 5 values per card, with additional values continued on succeeding cards; N=number of linear combinations.

14.4.3 CONTROL CARDS

Table 14-1 lists the control cards and available options for the TRSTAT processor.

14.4.4 FIELD DEFINITIONS

No field definition cards are input to TRSTAT.

14.4.5 DECK SETUP

The deck setup for the TRSTAT processor is given in figure 14-1.

14.5 CARD OUTPUT

The transformed statistics deck will be output in the same format as the module STAT deck.

---

[a]Unlike the B-matrix described in section 3.1.4.2, the A-matrix deck contains the additive vector.

14.6 SAMPLE COMPUTER RUNS

Figures 14-2 and 14-3 are sample program listings and output from the TRSTAT processor.

14.7 RESTRICTIONS

The system-related restrictions in section 17 apply to this processor.

The maximum dimension of the A-MATRIX is 15 by 30, and the maximum number of elements in the additive b-vector is 30.

14.8 DIAGNOSTIC MESSAGES

Message	Explanation
*** BAD SUPERVISOR CONTROL CARD SETUP9 ***	Invalid control card. Check spelling of keyword.
NUMBER OF CHANNELS FROM STAT FILE DOES NOT EQUAL THE NUMBER OF CHANNELS ON A-MATRIX FILE. CHANNELS ON STAT FILE = ______. CHANNELS ON A-MATRIX = ______.	Self-explanatory.
INVALID CONTROL CARD REJECTED *** SETUP9 ***	The parameter field of the control card is in error.

TABLE 14-1.– TRSTAT PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
A-MATRIX	Blank Default: Deck must be input	Initiates input of the A-matrix and b-vector. The A-matrix deck (see section 14.4.2 for format) immediately follows this card.
OPTION	P,O,T	P punches the transformed statistics; O prints the original statistics; and T prints the transformed statistics.
MODULE	Blank	Initiates input of the module STAT deck, which immediately follows this card. (See section 3.1.4.1 for module STAT deck format.)
STATFILE	INPUT/UNIT=N,FILE=M, OUTPUT/UNIT=L,FILE=S Default: N=1; M=1; L=9; S=1	N is the Fortran logical unit number to which the tape containing the statistics to be transformed has been assigned; M is the number of the file to be processed; L is the Fortran logical unit number to which the transformed statistics are to be output; and S is the number of the next file to be created on output SAVTAP file.

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 14-1.– Continued.

Keyword	Parameter and default values	Function
CHANNELS	$N_1, N_2, N_3, \cdots, N_k$ k=number of matrix channels$\leq$30 Default: None	N's are integer channel numbers referring to the SAVTAP file. The number of channels requested from SAVTAP must be equal to the number of channels on the A-matrix file.
SUBCLASS	$S_1, S_2, S_3, \cdots, S_k$ k$\leq$number of subclasses on SAVTAP$\leq$60 Default: Statistics for all subclasses defined	Transforms statistics for only subclasses $S_1, S_2, S_3, \cdots$.
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.

TABLE 14-1.– Concluded.

Keyword	Parameter and default values	Function
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

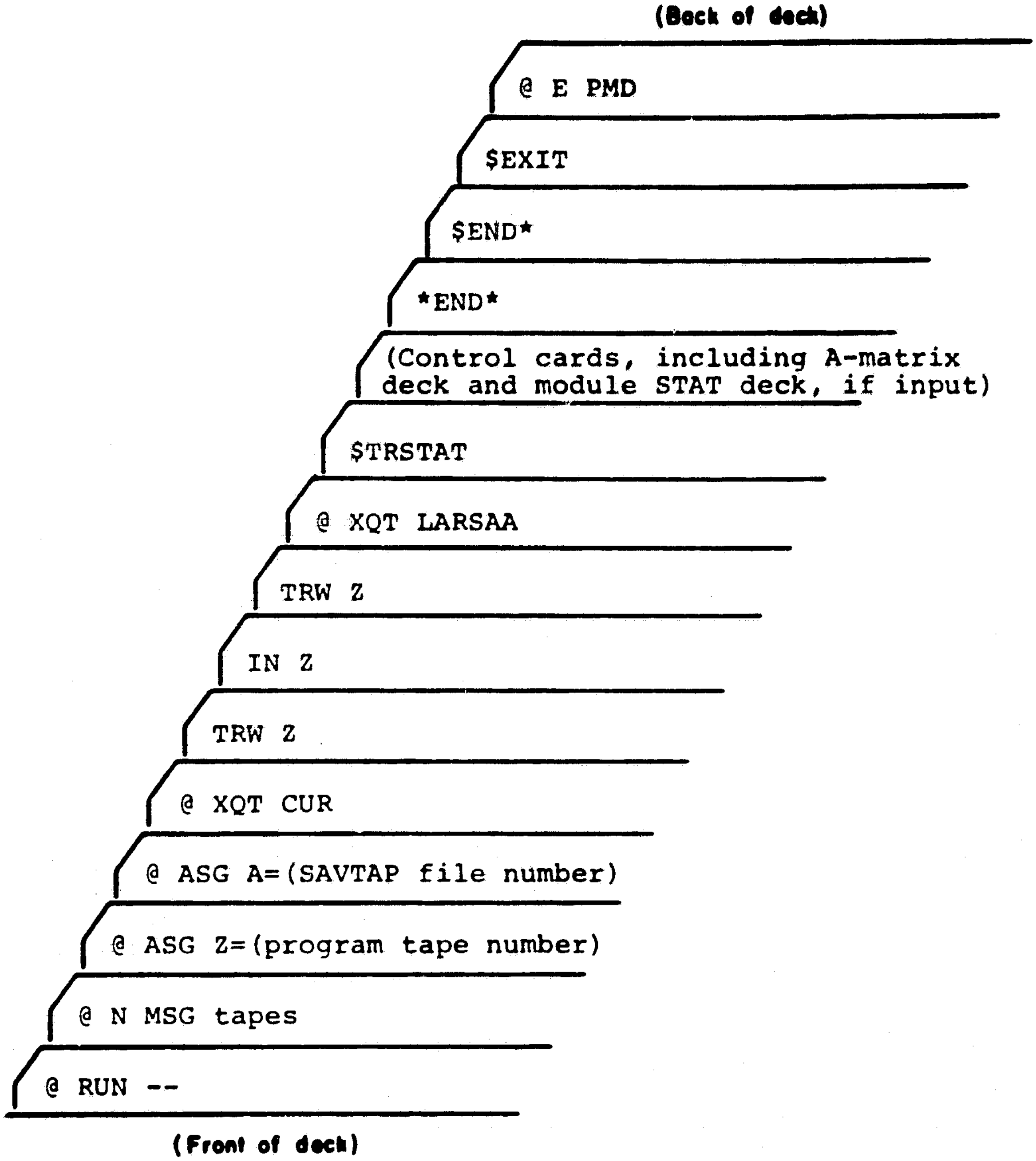


Figure 14-1.- Deck setup for executing the TRSTAT processor with the module STAT deck.

Card	Sample program listing	Comment/command
1	Z RUN L78362,TF,LVIII,1659,C387,C,5,5 WILLS	EXEC 2 run card
2	ASG G	Assign output statistics file (SAVTAP) to Fastrand
3	ASG A	Assign module STAT deck file (SAVTAP) to Fastrand
4	ASG Z=X09972	Assign EOD-LARSYS program tape
5	XQT CUR	Execute Univac complex utility routine
6	TRW Z	Rewind program tape
7	IN Z	Read program tape into system
8	TRW Z	Rewind program tape
9	XQT LARSAA	Execute EOD-LARSYS
10	$TRSTAT	Execute TRSTAT processor
11	MODULE CARDS	Initiate input of module STAT deck
12	A-MATRIX	Initiate input of A-matrix deck
13	*END*	End of control cards
14	$END*	End of card input
15	$EXIT	Exit EOD-LARSYS
16	E PMD	Give a core dump if run errs

Figure 14-2.– Sample program listing for the TRSTAT processor using defaults.

```
$ISOCLS

INPUT SUMMARY

    CHANNE     DATA=1,2,3,4
    *END*

YOU HAVE SELECTED THE FOLLOWING PARAMETER VALUES AND   OPTIONS

STOP AFTER   10 ITERATION(S)
ALLOW A MINIMUM OF    30 PIXELS PER CLUSTER
PRINT A CLUSTER SUMMARY EVERY   20 ITERATION(S)
PRINT A CLUSTER MAP EVERY   20 ITERATION(S)
ALLOW A MAXIMUM OF   60 CLUSTERS PER CLASS
THE STATISTICS FILE WILL BE WRITTEN AFTER    1 CLASS(ES) HAVE BEEN CLUSTERED
CHANNELS ARE---  1  2  3  4
DLMIN =  3.200
STDMAX=  4.500

INPUT IMAGE DATA TAPE INFORMATION

    FORMAT                    UNIVERSAL
    NO. OF CHANNELS              20
    NO. OF PIXELS/LINE          196
    FIRST SCAN LINE NO.           1
    FIRST PIXEL REFERENCE PT      1
```

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Figure 14-2.— Continued.

C-5

LYNDON B. JOHNSON SPACE CENTER 06 MAY 77
HOUSTON, TEXAS

FIELDS TO BE CLUSTERED FOR CLASS ALL

	FIELD NAME	SAMPLE INC.	LINE INC.	VERTICES (SAMPLE, LINE)
1	FLD1	1	1	(1, 1) (196, 1) (196, 117) (1, 117)

Figure 14-2.– Continued.

FINAL CLUSTER SUMMARY FOR CLASS ALL

TOTAL NUMBER OF CLUSTERS = 4

TOTAL NUMBER OF POINTS = 22932

CLUSTER	SYMBOL	POINTS IN CLUSTER
1	1	2175
2	2	10480
3	3	5487
4	4	4790

MEANS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	32.61	35.25	39.56	19.40
2	21.67	18.74	20.95	10.28
3	22.22	18.69	29.24	16.19
4	26.91	26.75	29.64	14.75

STANDARD DEVIATIONS

CLUSTER	CH(1)	CH(2)	CH(3)	CH(4)
1	2.34	3.83	3.54	1.77
2	1.84	2.83	3.07	2.12
3	1.67	2.76	3.44	2.40
4	1.65	2.41	3.31	2.16

DISTANCES BETWEEN CLUSTERS

CLUSTER	1	2	3	4
1	.00	10.35	8.06	5.50
2	10.35	.00	3.66	5.50
3	8.06	3.66	.00	4.27
4	5.50	5.50	4.27	.00

Figure 14-2.— Continued.

FL01

TOTAL NUMBER OF POINTS IN THIS FIELD 22932

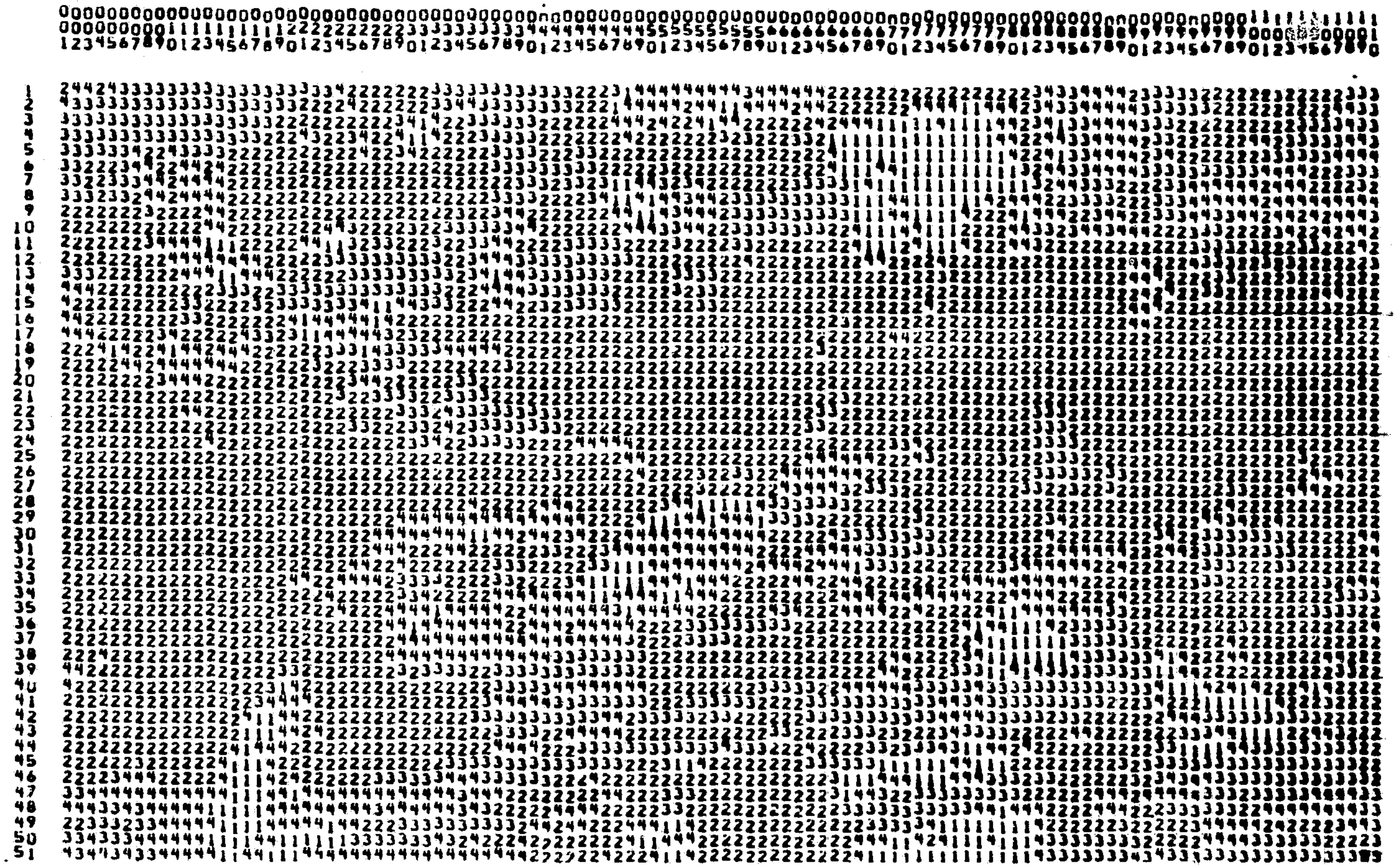

Figure 14-2.— Continued.

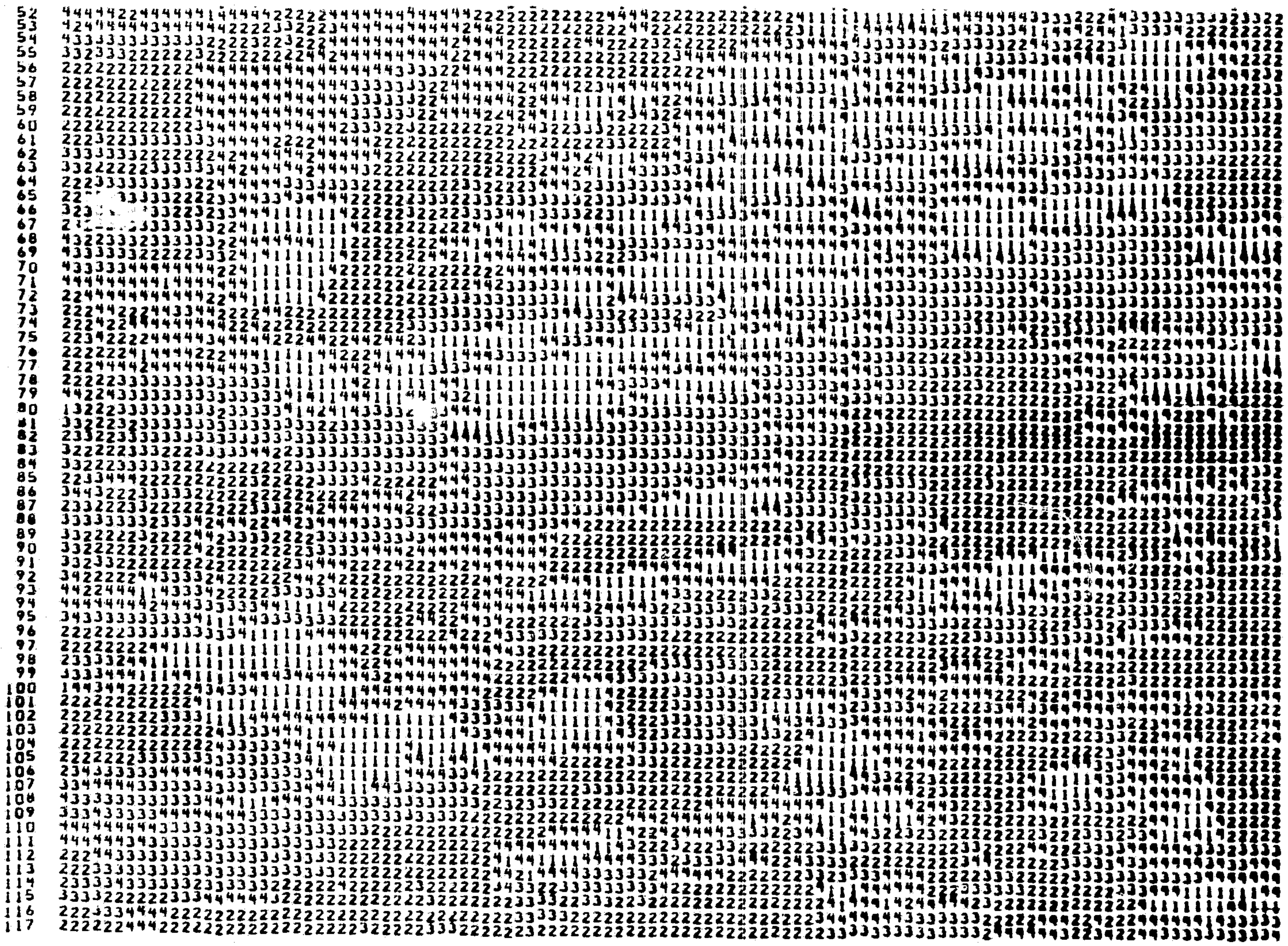

Figure 14-2.— Continued.

POINTS PER CLUSTER IN THIS FIELD

CLUSTER	SYMBOL	POINTS
1	1	2175
2	2	10480
3	3	5487
4	4	4790

Figure 14-2.– Continued.

```
                              LYNDON B. JOHNSON SPACE CENTER                06 MAY 77
                                      HOUSTON,TEXAS

THE STATISTICS FILE FOR    1 CLASSES AND    4 SUBCLASSES HAS BEEN WRITTEN
THE STATS WERE WRITTEN ON FILE    1
THE STATS FOR A PARTICULAR CLASS OR SUBCLASS SHOULD BE REFERRED TO IN LATER RUNS BY
THE FOLLOWING NAMES AND NUMBERS (WHICHEVER APPLICABLE)

   CLASS  1  ALL        SUBCLASSES (TOTAL=   4)

                             1  ALL001
                             2  ALL002
                             3  ALL003
                             4  ALL004
TIME FOR ISOCLS      1.088
```

Figure 14-2.— Continued.

LYNDON B. JOHNSON SPACE CENTER 06 MAY 77
HOUSTON, TEXAS

```
STRSTAT
   A-MATR
   OPTION    0,T
   STATFI    INPUT/UNIT=1,FILE=1
   STATFI    OUTPUT/UNIT=1,FILE=2
   CHANNE    1,2,3,4
   *END*
```


Figure 14-2.– Continued.

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HOUSTON, TEXAS

06 MAY 77

B-VECTOR

.1577+01 .1667+01 .1208+02 .1000+01

A-MATRIX

NO. OF COMBINATIONS = 4
NO. OF CHANNELS = 4

COMBINATIONS	CH(1)	CH(2)	CH(3)	CH(4)
1	.9960+00	.0000	.0000	.0000
2	.0000	.1001+00	.0000	.0000
3	.0000	.0000	.8065+00	.0000
4	.0000	.0000	.0000	.8935+00

Figure 14-2.– Continued.

SUBCLASS ALL001

MEAN	32.61	35.25	39.56	19.40
COVARIANCE MATRIX				
	5.98			
	7.99	19.68		
	5.01	7.95	12.53	
	1.69	2.58	5.10	3.12

SUBCLASS ALL002

MEAN	21.67	18.74	20.95	10.28
COVARIANCE MATRIX				
	3.38			
	4.17	8.01		
	2.00	2.45	9.41	
	.99	.39	5.42	4.98

Figure 14-2.— Continued.

SUBCLASS ALL003
MEAN 22.22 18.69 29.29 10.19
COVARIANCE MATRIX

2.79			
3.50	7.69		
.08	-1.08	11.81	
-.93	-2.20	7.00	5.76

SUBCLASS ALL004
MEAN 26.91 26.75 29.69 19.75
COVARIANCE MATRIX

2.73			
2.79	5.80		
2.58	3.13	10.99	
1.17	1.26	6.09	9.65

SEND*

Figure 14-2.— Continued.

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HOUSTON, TEXAS
TRANSFORMED

SUBCLASS ALL001
MEAN 34.06 5.20 43.99 18.33
COVARIANCE MATRIX

5.43			
.75	.15		
4.02	.69	8.15	
1.50	.23	3.68	2.49

SUBCLASS ALL002
MEAN 23.16 3.54 28.98 10.18
COVARIANCE MATRIX

3.35			
.42	.08		
1.61	.20	6.12	
.44	.03	3.91	3.58

Figure 14-2.— Continued.

TRANSFORMED

SUBCLASS ALL003

MEAN	23.71	3.53	35.06	15.42
COVARIANCE MATRIX				
	2.76			
	.35	.08		
	.54	-.09	7.68	
	-.39	-.20	5.04	4.60

SUBCLASS ALL004

MEAN	28.38	4.34	35.99	14.18
COVARIANCE MATRIX				
	2.71			
	.28	.06		
	2.07	.25	7.15	
	1.04	.11	4.35	3.71

TIME FOR TRSTAT .036 MINUTES

Figure 14-2.— Concluded.

Card	Sample program listing						Comment/command
1	Z RUN L78362,TF,LVIII,1659,C387,C,5,10				WILLS		EXEC 2 run card
2	ASG A						Assign SAVTAP to Fastrand
3	ASG Z=X09972						Assign EOD-LARSYS program tape
4	ASG C=X19977						Assign MSS DATAPE
5	XQT CUR						Execute Univac complex utility routine
6	TRW Z						Rewind program tape
7	IN Z						Read program tape into system
8	TRW Z						Rewind program tape
9	XQT LARSAA						Execute EOD-LARSYS
10	$ISOCLS						Execute ISOCLS processor
11	CHANNEL DATA=1,2,3,4						Channels to be used in computations
12	*END*						End of control cards input
13	CLASSNAME ALL						CLASSNAME card
14	FIDLS						Field definition of segment to cluster
15	$END*						End of card input to ISOCLS
16	$TRSTAT						Execute TRSTAT processor
17	A-MATRIX						Initiates input of A-matrix
18	4 4 1 2 3 4						
19		.9960	.0	.0	.0	.0	Transformed A-matrix deck
20		.1001	.0	.0	.0	.0	
21		.8065	.0	.0	.0	.0	
22		.8935					
23		1.567	1.667	12.08		3.852	Additive bias vector
24	OPTION C,T						Print original and transformed statistics
25	STATFILE INPUT/UNIT=1,FILE=1						Transform statistics in unit A, file 1
26	STATFILE OUTPUT/UNIT=1,FILE=2						Output transformed statistics in unit A, file 2
27	CHANNEL 1,2,3,4						Channels in unit A, file 1 that are to be transformed
28	*END*						End of control card input
29	$END*						End of card input to TRSTAT
30	PMD						Give a core dump if run errs

Figure 14-3.– Sample program listing and output for the TRSTAT processor using options and executing back to back with ISOCLS.

15. N-DIMENSIONAL HISTOGRAM PROCESSOR – NDHIST

The NDHIST processor computes an n-dimensional histogram of areas of the MSS data tape (DATAPE) of which the user has requested scatter plots. The pixel dimensions are user specified by the plotting channels, and the histogrammed pixels are output on the NDIM file. The file is written as an interface to the SCTPRL processor.

15.1 PROCEDURES

The number of channels (dimensions) used in histogramming is specified by means of the CHANNELS control card defined in table 15-1. The plotting channels are the primary input channels. The color channels are for further delineation of the frequency determination. Thus, the total dimensionality n of the histogramming is the number of plotting channels plus the number of color channels.

In the case of $n > 2$, the dimensionality is reduced to 2 in the SCTRPL processor by means of a linear transformation.

Composed of the plotting channels, each unique (positional) pixel within the field designates the position of a pixel on the scatter plot tape, PLOTAP. The frequency of each positional pixel is determined as a function of the color channels (if input) and the plotting channels.

If only plotting channels are input, both the positional pixel and its frequency are calculated using plotting channel data. If both plotting and color channels are input, the positional pixel is a function of the plotting channels, and the frequency is a function of both sets of channels as follows:

a. If, for each positional pixel x, there is only one unique color pixel y, $f(x,y) = f(x,y) + 1$.

b. If, for each positional pixel x, there are two or more color pixels y_i, $i = 1,2,3,\cdots,n$, and $n \leq$ total pixels in scene, $f(x,y_i) = f(x,y_j) + 1$ only if $f(x,y_i) = f(x,y_j)$ for $i \neq j$.

c. If, for two or more positional pixels x_i, $i = 1,2,3,\cdots,n$, and $n \leq$ total pixels in the scene, there is only one unique color pixel y, $f(x_i,y) = f(x_j,y) + 1$ only if $f(x_i,y) = f(x_j,y)$ for $i \neq j$.

The color assignment for each unique pixel may be optionally set by the NDHIST or the SCTRPL processor. If applicable, the color codes are output on the NDIM file. The color codes may be set using the following information.

a. The original radiance value of the pixel (see CHANNELS control card, table 15-1).

b. The mean value of the cluster or subclass to which the pixel was assigned during clustering or classification. In exercising this option, the user must input a classification or cluster map (see MAPFIL control card, table 15-1) to this processor. To execute the SCTRPL processor, a SAVTAP file related to the MAPFIL must be input (see CHANNELS and STATFILE control cards, section 16, table 16-1). The subclass or cluster numbers assigned to the pixel during classification or clustering are stored on the NDIM file, passed to the SCTRPL processor, and used for retrieving the means from the SAVTAP file.

c. The mean value of the test or training field from which the pixel was extracted.

d. User-defined colors (see COLOR control card, table 16-1).

e. From any pass on the MSS data tape when using multiregistered Landsat data (see CHANNELS control card, table 15-1).

The areas selected for histogramming are defined by test and/or training fields. The manner in which the fields are collected or grouped for histogramming is user controlled by input parameters. The data vectors may be histogrammed collectively on a class, subclass, or per-field level. The maximum number of fields input on any level is 200, and the maximum number of unique data vectors accumulated on any level is 12 000 divided by one-fourth the number of plotting channels.

A functional flow diagram of the NDHIST processor is given in figure 15-1.

15.2 INPUT FILES

An MSS data tape (DATAPE) must be input to the NDHIST processor. The tape assignment defaults to logical unit C (Fortran unit 3); however, by input of the DATAFILE control card, the user may assign any available logical unit. (See table 4-1 for file assignments and section 3.2, MSS Image Data Tapes, for further information.) Optionally, a classification or cluster MAPFIL tape may be input (see MAPFIL control card).

15.3 OUTPUT FILES

A multifile tape is always output (NDIM file). It is an interface to the SCTRPL processor and must be assigned to tape or Fastrand. No file-skipping capability is available; the first file created is always file 1. (See HISFIL control card, table 15-1, and appendix H.)

15.4 SCRATCH FILES

The NDHIST processor dynamically assigns random access drum storage for the histogram counters, color codes, identification information, and (optionally) the pixel assignment from the classified or clustered image tape (MAPFIL).

15.5 CARD INPUT

15.5.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$NDHIST

This card directs the system monitor routine to select the NDHIST processor and initiates loading of all the NDHIST routines into the system.

15.5.2 SYSTEM CARD DECKS

No special system card decks are required for the NDHIST processor.

15.5.3 CONTROL CARDS

Table 15-1 lists the control cards and available options for the NDHIST processor.

15.5.4 FIELD DEFINITIONS

The field cards, which immediately follow the *END* control card, define the areas to be histogrammed, and the OPTION control card determines the level of histogramming. The fields may be ordered in one of four ways:

a. As input to STAT (section 8.4.4)

b. As input to ISOCLS (section 9.5.4)

c. As input to CLASSIFY (section 11.5.4)

d. As a user-defined field (section 3.1.3)

For example:

```
*END*
CLASSNAME    WHEAT
SUBCLASS     WHEAT1
(Field card 1)
(Field card 2)
SUBCLASS     WHEAT2
(Field card 3)
CLASSNAME    NONWH
SUBCLASS     NONWH1
(Field card 4)
SUBCLASS     NONWH2
(Field card 5)
SUBCLASS     NONWH3
(Field card 6)
(Field card 7)
$END*
```

If the histogram is accumulated on class bases, fields 1, 2, and 3 are histogrammed collectively and output as data file 1; and fields 4, 5, 6, and 7 are histogrammed collectively and output as data file 2.

If the histogram is accumulated on subclass bases, fields 1 and 2 are histogrammed collectively and output as data file 1; field 3 is histogrammed and output as data file 2; field 4 is histogrammed and output as data file 3; field 5 is histogrammed and output as data file 4; and fields 6 and 7 are histogrammed collectively and output as data file 5.

If the histogram is performed on per-field bases, each field is histogrammed separately and output to a file, making a total of seven data files created.

On a cumulative histogram, a maximum of 200 fields may be input.

See section 3.1.3 for format of the field definition card.

15.5.5 DECK SETUP

The deck setup for the NDHIST processor is given in figure 15-2.

15.6 CARD OUTPUT

The NDHIST processor does not provide punched card output.

15.7 SAMPLE COMPUTER RUNS

Sample runs are given in figures 15-3 and 15-4 and appendix H.

15.8 RESTRICTIONS

The system-related restrictions in section 17 apply to this processor. Other restrictions are as follows.

- A maximum of 16 channels may be histogrammed.
- A maximum of 4 channels may be used for color codes.
- The maximum of unique vectors to be histogrammed is

$$n \leq \frac{12\ 000}{1/4(\text{number of channels})} \tag{15-1}$$

- A maximum of 4000 words of storage is allowed for storing the MSS data. The equation for computing maximum number of pixels is

$$n \leq \frac{4000}{[\text{number of channels}(\text{number of samples per scan line})]} \tag{15-2}$$

15.9 DIAGNOSTIC MESSAGES

Message	Explanation
INVALID CONTROL CARD - IGNORED.	Check spelling of keyword.
ERROR ON CHANNELS CARD.	Check parameter field of CHANNELS control card.
ERROR ON DATA FILE CARD.	Check parameter field of DATAFILE control card.
ERROR ON MAP FILE CARD.	Check parameter field of MAPFIL control card.

Message	Explanation
ERROR ON N-DIM HISTOGRAM FILE CARD.	Check parameter field of HISFIL control card.
ERROR ON OPTION CARD.	Check parameter field of OPTION control card.
-- VECTORS WERE NOT HISTO-GRAMMED, BUT USED IN COMPUTING FIELD MEANS, IF APPLICABLE.	The histogrammed vector table is full. N number of unique vectors were not histogrammed.
CORE LIMITS EXCEEDED. MAXIMUM NO. OF VECTORS ACCEPTED IS ___.	Self-explanatory.
TOO MUCH DATA REQUESTED. REDUCE NO. OF SAMPLES PER SCAN LINE AND/OR NO. OF CHANNELS.	Self-explanatory.
NOT ENOUGH DRUM SPACE TO STORE MAP TAPE DATA.	Reduce amount of data being processed.

TABLE 15-1.– NDHIST PROCESSOR OPTIONS AND CONTROL CARDS

[All m and n are integers.]

Keyword (a)	Parameter and default values (b)	Function
CHANNELS	PLOT=$n_1,n_2,n_3,\cdots,n_i$, COLOR=$m_1,m_2,m_3,\cdots,m_j$ Default: None	The n's are the channels for determining the position (PLOT) of the pixels to be output on the PLOTAP tape ($i \leq 16$). If $i=2$, n_1 defines the sample location and n_2 the line location on the scatter plot tape (PLOTAP). If $i>2$, the pixels will be transformed to two components in the SCTRPL processor; component 1 will define the sample location and component 2 the line location on the scatter plot tape (PLOTAP). The m's represent the channels for the color codes ($j \leq 4$). If the COLOR channels are input, the histogram is a function of both the PLOT and COLOR channels; if the COLOR channels are omitted the histogram is a function of only the PLOT channels. (See section 16 for further information.)

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 15-1.– Continued.

Keyword	Parameter and default values	Function
DATAFILE	UNIT=N,FILE=M Default: N=3,M=1	N is the logical unit number assigned to the MSS data tape (DATAPE); M is the file number of the data to be processed.
MAPFILE	UNIT=N,FILE=M Default: None	N is the logical unit number assigned to the MAPFIL tape; M is the file number of the data to be processed. (The order of the fields to be histogrammed must correspond to the order of the clustered or classified fields on the input MAPFIL tape.)
HISFIL	UNIT=N Default: N=4	The logical unit number assigned to the NDIM file.
OPTION	CLASS Default: Field bases	Fields will be histogrammed on class bases.
OPTION	SUBCLS Default: Field bases	Fields will be histogrammed on subclass bases.
OPTION	FIELD Default: Field bases	Fields will be histogrammed on per-field bases.
OPTION	MEANS	The means of each field will be computed for the COLOR channels on the CHANNELS card and output on the NDIM file.

TABLE 15-1.– Concluded.

Keyword	Parameter and default values	Function
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

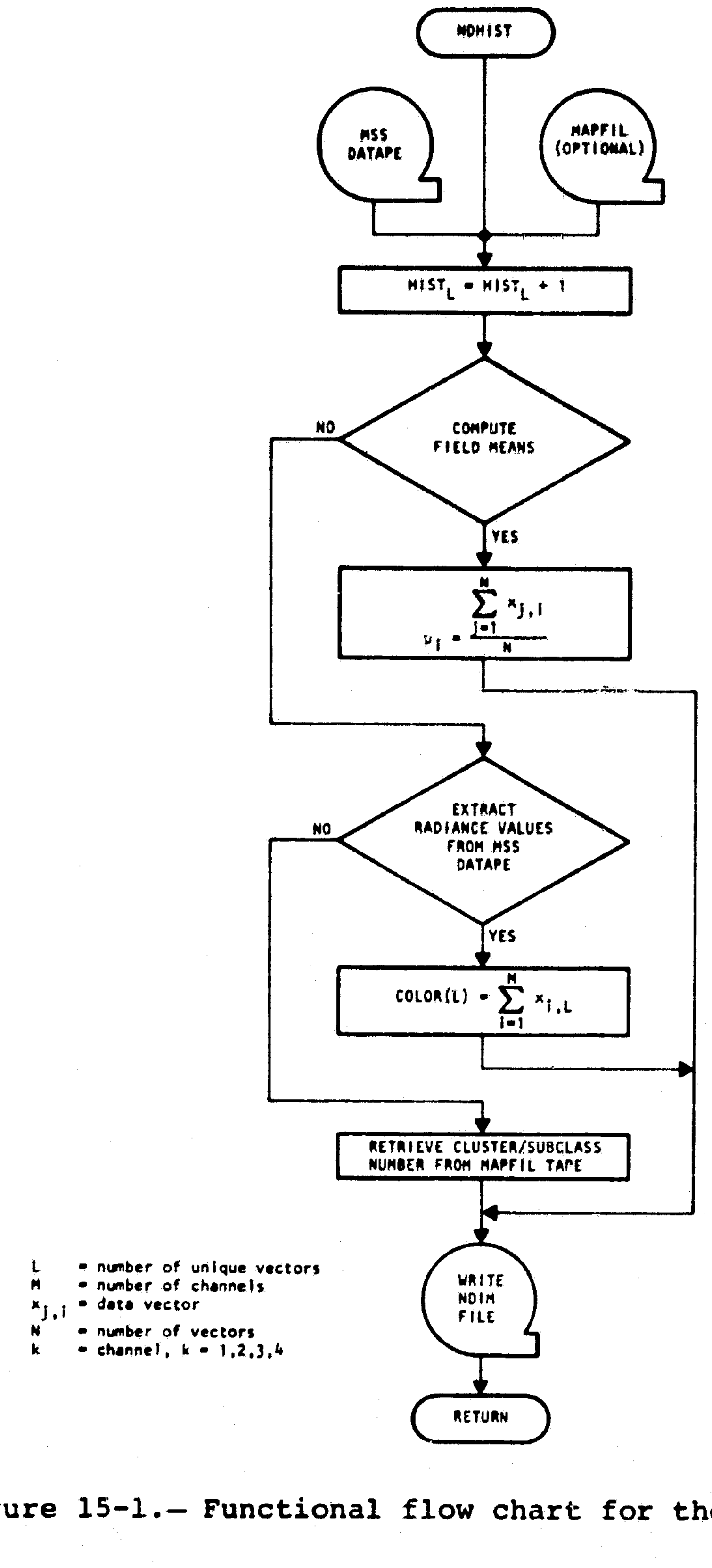
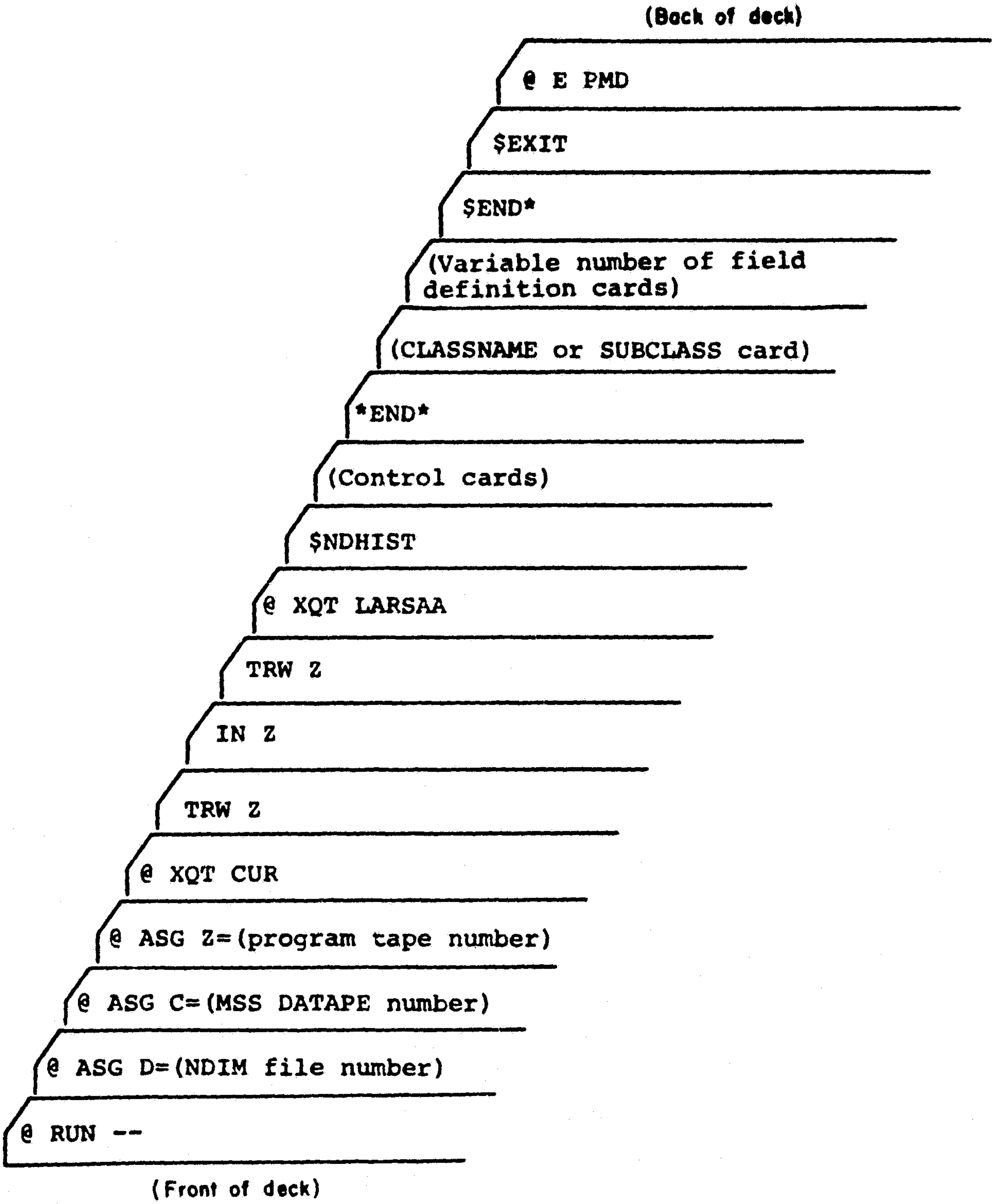


Figure 15-1.— Functional flow chart for the NDHIST processor.



(a) For independent execution.

Figure 15-2.– Deck setup for the NDHIST processor.

(Back of deck)

(Field definition card — same as the one used to create MAPFIL)

END

(Control cards)

$NDHIST

@ XQT LARSAA

TRW Z

IN Z

TRW Z

@ XQT CUR

@ ASG Z=(program tape number)

@ ASG N=(MAPFIL file number)

@ ASG E=(PLOTAP file number)

@ ASG A=(SAVTAP file number) } Saved from a previous execution of the STAT processor

@ ASG C=(MSS DATAPE number)

@ ASG D,H } Assigns NDIM file and BMFILE to Fastrand

@ RUN --

(Front of deck)

(b) For execution back to back with SCTRPL.

Figure 15-2.— Continued.

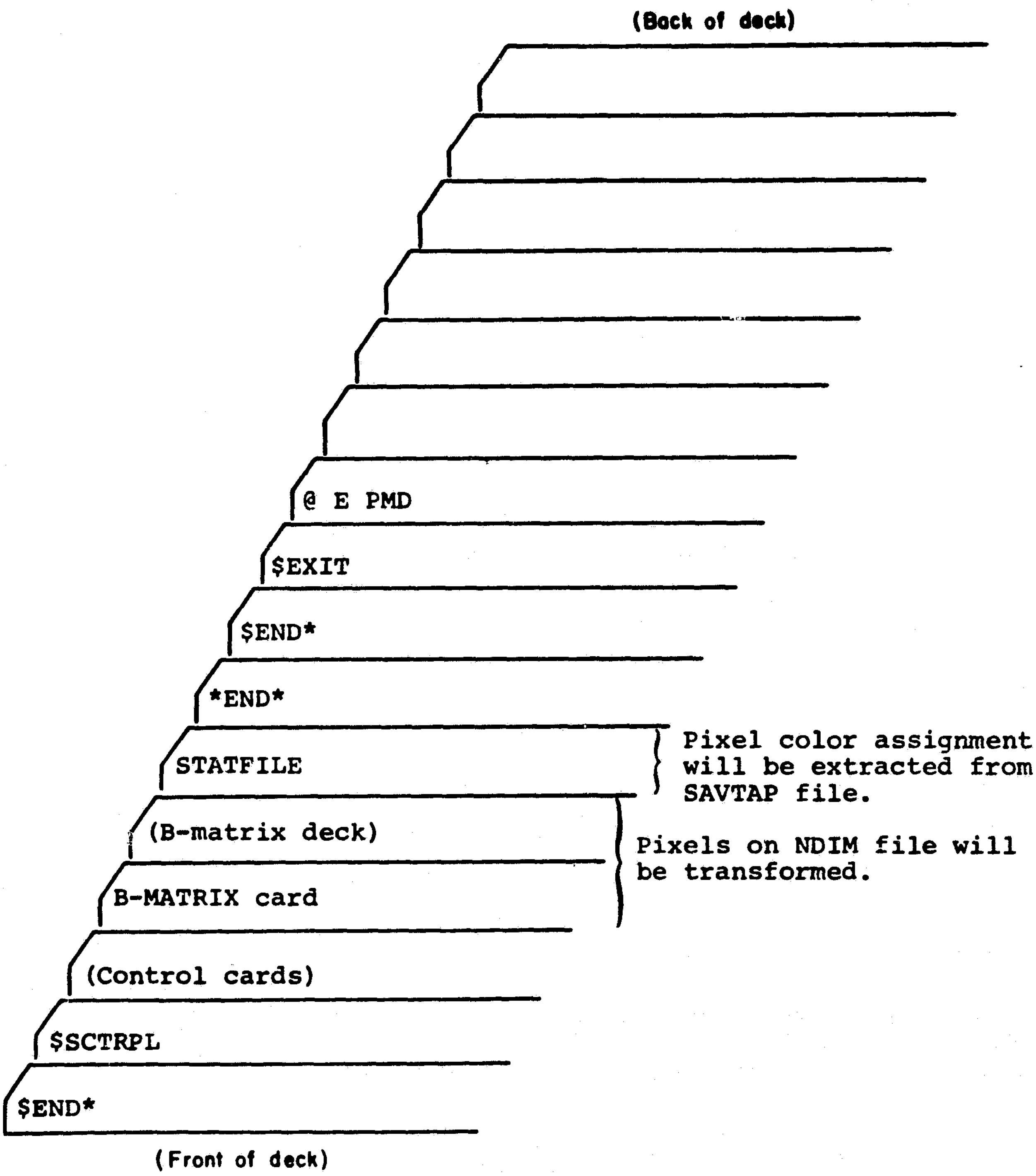


Figure 15-2.– Concluded.

Card	Sample program listing			Comment/command
1	Z RUN L78362,TF,LVIII,1659,C387,C,5,10		WILLS	EXEC 2 run card
2	ASG D,E			Assign NDIM and PLOTAP to Fastrand
3	ASG C=X17686			Assign MSS DATAPE
4	ASG Z=X12432			Assign EOD-LARSYS program tape
5	XCT CUR			Execute Univac tape complex utility routine
6	TRW Z			Rewind program tape
7	IN Z			Read program tape into system
8	TRW Z			Rewind program tape
9	XQT LARSAA			Execute EOD-LARSYS
10	$NDHIST			Execute NDHIST processor
11	CHANNEL	PLOT=2,3,COLOR=1,2,3,4		Pixels from channels 2 and 3 are histogrammed; pixels from channels 1, 2, 3, and 4 are the color assignments for the histogrammed pixels
12	*END*			End of control card input
13	FLD1	(1,1),(1,1),(196,1),(196,117),(1,117)		Field definition of segment to be histogrammed
14	$END*			End of all input for NDHIST
15	$SCTRPL			Execute SCTRPL processor
16	PIXPLT	FREQ		Output a line printer pixel frequency plot
17	*END*			End of control card input
18	$END*			End of all input for SCTRPL
19	$EXIT			Exit EOD-LARSYS
20	E PRD			Give a core dump if the run errs

Figure 15-3.– Sample program listing and output for the NDHIST processor using defaults and executing back to back with the SCTRPL processor.

```
                                        LYNDON B. JOHNSON SPACE CENTER          23 FEB 77
                                              HOUSTON,TEXAS

*NDHIST

          INPUT SUMMARY

CHANNE    PLOT=2,3,COLOR=1,2,3,4
*END*

USER HAS REQUESTED THE FOLLOWING OPTIONS :

HISTOGRAM DATA VECTORS FROM CHANNELS  2  3
COLOR-CODES ARE FROM CHANNELS  1  2  3  4
HISTOGRAM FIELDS ON PER FIELDS BASES

INPUT IMAGE DATA TAPE INFORMATION

    FORMAT                      UNIVERSAL
    NO. OF CHANNELS                20
    NO. OF PIXELS/LINE            196
    FIRST SCAN LINE NO.             1
    FIRST PIXEL REFERENCE PT        1
```

Figure 15-3.— Continued.

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23 FEB 77

INPUT TEST FIELDS

FIELD	CLASS	SUBCLASS	VERTICES (SAMPLE, LINE)
1 FLD 1	0		(1, 1) (196, 1) (196, 117) (1, 117)

TOTAL NO. OF VECTORS = 1970
TOTAL NO. OF UNIQUE VECTORS = 339

TIME FOR NUMIST .382 MINUTES

Figure 15-3.– Continued.

```
                                   LYNDON B. JOHNSON SPACE CENTER            25 FEB 77
                                          HOUSTON,TEXAS

SSGTRPL

INPUT SUMMARY

PIXPLT    FREQ
*END*

USER HAS SELECTED THE FOLLOWING OPTIONS :

LINE PRINTER PIXEL FREQ. PLOT
BACK GROUND-COLOR FOR SPECTRAL PLOTS WILL BE WHITE
COLOR-CODES ARE COMING FROM RADIANCE VALUES STORED ON N- DIM HIST FILE
```

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Figure 15-3.— Continued.

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HOUSTON, TEXAS

23 FEB 77

INPUT TEST FIELDS

FIELD	CLASS	SUBCLASS	VERTICES (SAMPLE,LINE)
1 FLD 1			(1, 1) (196, 1) (196, 117) (1, 117)

SCATTER PLOT TAPE PARAMETERS

NO. OF LINES PER FILE = 101
NO. OF SAMPLES PER LINE = 101

XLO = 0 YLO = 0
XHI = 100 YHI = 100

Figure 15-3.– Continued.

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23 FEB 77

PIXEL FREQUENCY SCATTER PLOT

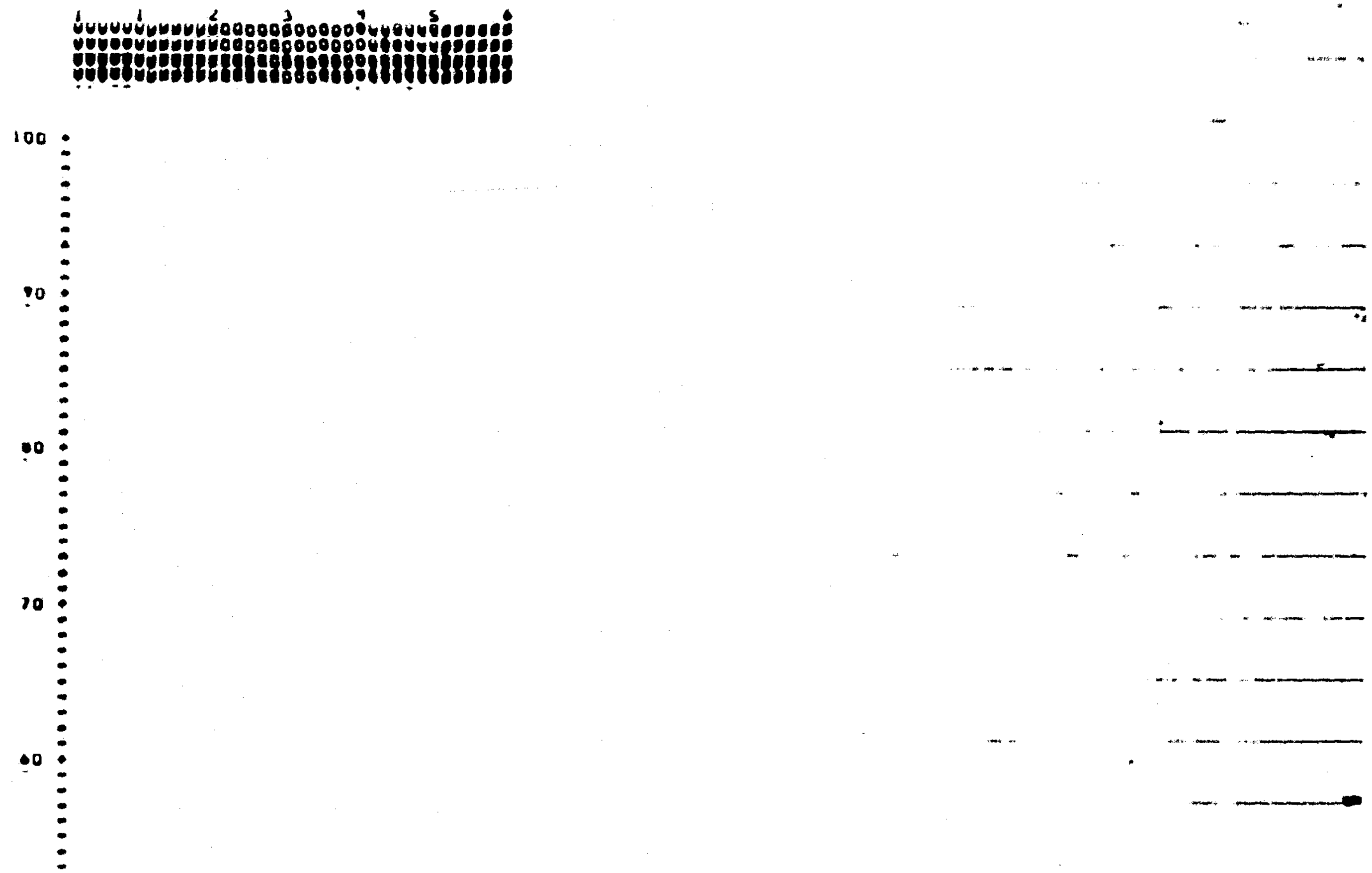

Figure 15-3.— Continued.

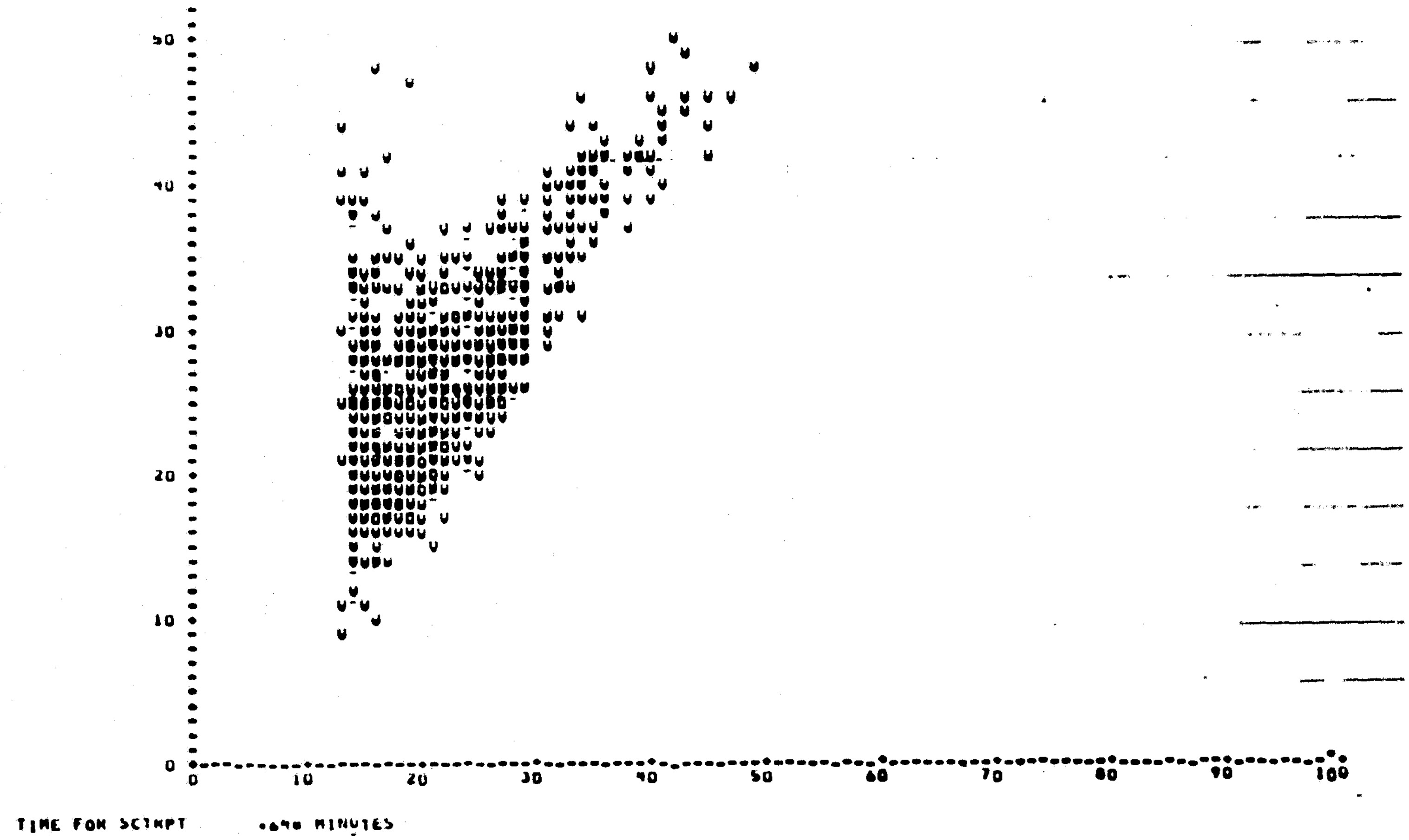

Figure 15-3.– Concluded.

Card	Sample program listing		Comment/command
1	Z RUN L78362,TF,LVIII,1659,C387,C,5,5	WILLS	EXEC 2 run card
2	ASG Z=X09972		Assign EOD-LARSYS program tape
3	ASG C=X19977		Assign MSS DATAPE
4	ASG N=X11221		Assign previously saved MAPFIL
5	ASG D		Assign NDIM to Fastrand
6	XQT CUR		Execute Univac complex utility routine
7	TRW Z		Rewind program tape
8	IN Z		Read program tape into the system
9	TRW Z		Rewind program tape
10	XQT LARSAA		Execute EOD-LARSYS program
11	$NDHIST		Execute NDHIST processor
12	CHANNEL PLOT=1,2,3,4		Histogram channels 1, 2, 3, and 4
13	DATAFILE UNIT=3,FILE=1		Process file 1 of MSS DATAPE
14	MAPFILE UNIT=16,FILE=1		Process file 1 of MAPFIL
15	HISFIL UNIT=4		Output NDIM on unit D
16	OPTION FIELD		Output each histogrammed field on a separate file
17	*END*		End of control card input
18	FIELD1 (4,4),(1,10),(100,10),(101,20),(20,21)		Field definition of first segment to be histogrammed (file 2 on HISFIL*)
19	FILED1 (1,1),(5C,61),(61,65),(30,8C),(12,79)		Field definition of second segment to be histogrammed (file 3 on HISFIL)
20	$END*		End of input
21	$EXIT		Exit program
22	E PMD		Give a core dump if run errs

*File 1 is the header record.

Figure 15-4.— Sample program listing for the NDHIST processor using options.

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16. SCATTER PLOT PROCESSOR - SCTRPL

The SCTRPL processor reads the NDIM file written by the NDHIST processor, determines the location of each unique data vector on the scatter plot, and outputs the spectral plot in the Universal format. A scatter plot is created and output to tape for each file stored on NDIM.

The location (line and sample intersection) of each pixel on the two-axis scatter plot will be computed using either the radiance values or two linear combinations of radiance values. (This option is controlled in section 15 by the CHANNELS control card, table 15-1.)

If the data vector is to be transformed (see B-MATRIX control card, table 16-1), the following equation and conditions will be applied:

$$y = Bx + c \tag{16-1}$$

where

y = a 2-by-1 vector

B = a 2-by-n vector, $n \leq 16$

x = an n-by-1 vector, $n \leq 16$

c = a 2-by-1 vector

If the transformed data are to be rescaled (see SCALE control card, table 16-1), the following equation will be applied:

$$y_i = \left(\frac{HI_i - LO_i}{R_i}\right) \cdot \times \; |MIN_i - z_i| \tag{16-2}$$

where

HI_i = an input parameter for the upper rescale limit for channel i

LO_i = an input parameter for the lower rescale limit for channel i

MIN_i = minimum value for channel i

Z_i = transformed data point for channel i

R_i = range (MAX_i - MIN_i) for channel i

Y_i = rescaled transformed data value for channel i

MAX_i = maximum value for channel i

The scatter plot is created and output line by line to tape. All the pixels belonging to a line, as determined by the second coordinate of the pixel, are collected; and, in the sample location determined by the first coordinate, the color assignment and frequency of occurrence of each pixel are output to tape as channels 1 through n, respectively. [See procedures for NDHIST processor (section 15.1) for definition of color assignments.]

The dimensions of the output tape are user controlled by the following input control cards, which are defined in greater detail in table 16-1 (the control cards for the SCTRPL processor) and table 15-1 (the control cards for the NDHIST processor).

Keyword	Parameters
SIZE	XLOW=0,XHIGH=128,XSIZ=129,YLOW=0, YHIGH=64,YSIZ=65
CHANNELS	PLOT=3,4,COLOR=5,6,7,8

The output tape will contain:

a. 129 samples per scan line with a maximum data resolution of 128 on channel 3.

b. 65 lines per file with a maximum data resolution of 64 on channel 4.

c. 5 channels with channels 1 through 4 containing the color pixel (determined by channels 5, 6, 7, and 8 on CHANNELS control card) and channel 5 the frequency.

d. A color pixel for each positional pixel determined by channels 3 and 4 on the CHANNELS control card.

If a MAPFIL tape containing the subclass or cluster numbers is input to the NDHIST processor, either a SAVTAP file related to the MAPFIL tape must be input (see STATFILE control card) or the user must input the color codes on cards (see COLOR control card).

Optionally, a line printer pixel frequency scatter plot will be output (see PIXPLT control card). The frequency of occurrence or log of frequency of occurrence will be represented by a symbol (see SYMBOL control card). The location of the symbol on the plot will be determined by the radiance value of the pixel. If the data have been transformed, then the data must be rescaled to exercise this option.

A functional flow diagram of the SCTRPL processor is given in figure 16-1.

16.1 INPUT FILES

The NDIM file created by NDHIST must be input. (See the HISFIL control card and appendix D for format of the NDIM tape.)

The SAVTAP file created by the STAT or ISOCLS processor optionally may be input. (See the STATFILE control card and section 4.1 for a description of the file.)

16.2 OUTPUT FILES

A multifile Universal-formatted tape containing the spectral plots and color keys, when applicable, will be output. (See the PLOTAP control card and appendix F for tape format.)

16.3 SCRATCH FILES

The program dynamically assigns random access drum storage for scratch files.

16.4 CARD INPUT

16.4.1 PROCESSOR CARD

The processor keyword is left justified starting in column 1. For example,

$SCTRPL

This card directs the system monitor routine to select the SCTRPL processor and initiates loading of all the SCTRPL routines into the system.

16.4.2 SYSTEM CARD DECKS

The module STAT and B-matrix decks may be input. See section 3 for formats.

16.4.3 CONTROL CARDS

Table 16-1 lists the options and control cards for the SCTRPL processor.

16.4.4 FIELD DEFINITIONS

Field definitions do not apply to this processor.

16.4.5 DECK SETUP

Figure 16-2 is a sample deck setup for the SCTRPL processor.

16.5 CARD OUTPUT

The SCTRPL processor does not provide punched card output.

16.6 SAMPLE COMPUTER RUNS

Figure 16-3 is a sample computer listing illustrating the use of all defaults.

Figure 16-4 is an example of executing various processors back to back with SCTRPL. The end result is to output the transformed cluster means as the color code for each pixel output to the PLOTAP file.

16.7 RESTRICTIONS

The system-related restrictions in section 17 apply to this processor.

If the color codes for the scatter plot tape PLOTAP are to be principal component (PC) colors, the user must ensure that the values are positive.

The maximum dimension of the B-matrix is 2 by 16; the maximum number of elements in additive vector b is 16.

The maximum number of channels on the output tape PLOTAP is 5. Color codes are the first n-1 channels; the frequency is the n*th* channel.

The maximum number of channels selected from the SAVTAP file is 4.

The maximum size of the output tape PLOTAP is 200 samples per scan line and 200 lines.

16.8 DIAGNOSTIC MESSAGES

Message	Explanation
INVALID CONTROL CARD -- IGNORED.	Check spelling of keyword.
ERROR ON CHANNELS CARD.	Check parameter field of CHANNELS card.
ERROR ON STAT FILE CARD.	Check parameter field of STATFILE card.
ERROR ON NDIM HISTOGRAM FILE CARD.	Check parameter field of HISFIL card.
ERROR ON OPTION CARD.	Check parameter field of OPTION card.
ERROR ON TAPE SIZE CARD.	Check parameter field of SIZE card.
ERROR ON SCATTER PLOT TAPE CARD.	Check parameter field of PLOTAP card.
ERROR ON SCALING CARD.	Check parameter field of SCALE card.
DATA MUST BE RESCALED BEFORE PIXEL FREQUENCY PLOT OPTION MAY BE SELECTED.	Transformed data must be rescaled for line printer plot.
NO. OF PLOTTING CHANNELS, NO. OF B-MATRIX CHANNELS MUST BE EQUAL. CHANNELS ARE _______, RESPECTIVELY.	Number of channels to be transformed, must equal the number of channels in transformation matrix.
ERROR IN POSITIONING N-DIM HIST FILE TO FILE _______.	Physical tape error occurred. Resubmit run.

Message	Explanation
A TOTAL OF _____ POINTS WERE NOT DISPLAYED ON THE LINE PRINTER GRAPH. THE POINTS WERE OUT OF RANGE IN EITHER THE X DIRECTION OR Y DIRECTION.	Data may be rescaled to a resolution of 100.

TABLE 16-1.– SCTRPL PROCESSOR OPTIONS AND CONTROL CARDS

Keyword (a)	Parameter and default values (b)	Function
CHANNELS	$n_1, n_2, n_3, \cdots, n_i$ $i \leq$ number of channels on SAVTAP ≤ 30 Default: First 4 channels from NDIM file	Statistics for these channels will be extracted from the SAVTAP file; n_i must be a subset of channels on the SAVTAP file.
STATFILE	UNIT=N,FILE=M Default: None	N is the logical unit number assigned to the SAVTAP file; M is the number of the file to be processed.
HISFIL	UNIT=N Default: N=4	N is the logical unit number assigned to the NDIM file.
PIXPLT	LOG	Line printer pixel scatter plot of the log of frequency of occurrence will be printed.
PIXPLT	FREQ	Line printer pixel scatter plot of the frequency of occurrence will be printed.
PIXPLT	RESCALE Default: No rescaling. XSIZ=101, YSIZ=101; the range for x-axis is XLOW+ XSIZ-1; the range for y-axis is YLOW+YSIZ-1.	The frequency of occurrence of the pixel for the line printer scatter plot will be rescaled to ranges XLOW, XHIGH, YLOW, and YHIGH. XSIZ will determine the number of bins on the x-axis; YSIZ, the

[a]The keyword must be left justified in card columns 1 through 10.

[b]The parameter and default values are in card columns 11 through 72 (beginning in any column past 10).

TABLE 16-1.— Continued.

Keyword	Parameter and default values	Function
		number of bins on the y-axis. (See SIZE control cards.)
COLOR	$(m_1),(m_2),\cdots,(m_p)$ or $L*(m_1)$, $K*(m_{L+1})$ L and K are integer repetition factors. Default: No user input of color codes	$m_1=n_1,n_2,\cdots,n_\ell$ is the color assignment for cluster 1; $m_2=n_1,n_2,\cdots,n_\ell$ is the color assignment for cluster 2; $m_p=n_1,n_2,\cdots,n_\ell$ is the color assignment for cluster n. $p\leq60$ and $\ell\leq4$; $0\leq n_i\leq255$.
SIZE	XSIZ=N Default: XSIZ=101	The number of samples per line to output on the scatter plot tape; $N\leq200$.
SIZE	YSIZ=N Default: YSIZ=101	The number of lines to output on the scatter plot tape; $N\leq200$.
SIZE	XHIGH=N Default: XHIGH=100	The upper limit of the radiance value for the sample axis (x-axis); $N\leq255$.
SIZE	XLOW=N Default: XLOW=0	The lower limit of the radiance value for the sample axis (x-axis); $0\leq N\leq XHIGH$.
SIZE	YHIGH=N Default: YHIGH=100	The upper limit of the radiance value for the line axis (y-axis); $N\leq255$.
SIZE	YLOW=N Default: YLOW=0	The lower limit of the radiance value for the line axis (y-axis); $0\leq N\leq255$.

TABLE 16-1.- Continued.

Keyword	Parameter and default values	Function
PLOTAP	UNIT=N Default: N=7	N is the logical unit number assigned to the spectral plot tape.
B-MATRIX	CARDS Default: None	The B-matrix is being input by cards.
B-MATRIX	FILE Default: None	The B-matrix is being input by file.
BVEC	$T_1, T_2, \cdots, T_n$ n=number of linear combinations in B-matrix$\leq$2 Default: T_n=0.0	Elements of the additive vector to be used in the transformation; T is a floating-point number.
BCKGND	N Default: N=255	If N=0, background will be black; if N=255, background will be white.
SCALE	FILE	The scale factors will be computed from the NDIM file.
SCALE	XMAX=T Default: XMAX will be computed from the NDIM file.[c]	The upper range for the transformation of the sample values (x-axis); T is a floating-point number.
SCALE	XMIN=T Default: XMIN will be computed from the NDIM file.[c]	The lower range for the transformation of the sample values (x-axis); T is a floating-point number.

[c]If one of the parameters XMIN, XMAX, YMIN, or YMAX is input, all four parameters must be input.

TABLE 16-1.– Continued.

Keyword	Parameter and default values	Function
SCALE	YMAX=T Default: YMAX will be computed from the NDIM file.[d]	The upper range for the transformation of the line values (y-axis); T is a floating-point number.
SCALE	YMIN=T Default: YMIN will be computed from the NDIM file.[d]	The lower range for the transformation of the line values (y-axis); T is a floating-point number.
SCALE	RESCALE Default: No rescaling of the transformed data.	The transformed data will be rescaled to the range of XLOW, XHIGH, YLOW, and YHIGH. (See SIZE control card.)
HED1	Any 60 characters beginning in column 11 Default: LYNDON B. JOHNSON SPACE CENTER	Replaces first header line with the indicated characters in the parameter field.
HED2	Any 60 characters beginning in column 11 Default: HOUSTON, TEXAS	Replaces second header line with the indicated characters in the parameter field.
DATE	Any 12 characters beginning in column 11 Default: Current date	Prints the indicated 12 characters in the right corner of the heading in place of the current date.

[d]If one of the parameters XMIN, XMAX, YMIN, or YMAX is input, all four parameters must be input.

TABLE 16-1.– Concluded.

Keyword	Parameter and default values	Function
SYMBOLS	$S_1, S_2, S_3, \cdots, S_k$ $k \leq 32$ Default: Two sets of 10 symbols overprinted	Character set separated by commas, with a maximum of 32 characters. The number of symbols/2 determines the number of bin levels. The first set of symbols is overprinted by the second set. A blank is not a legitimate character.
MODULE	Blank	Initiates the input of the module STAT deck which immediately precedes this card (see section 3.1.4.1 for format).
COMMENT	Any 60 characters beginning in column 11 Default: No comments printed	Prints a comment line using the 60 characters found in the parameter field.
END	Blank	Signals the end of the control cards.
$END*	Blank	Signals the end of all card input for the processing function.

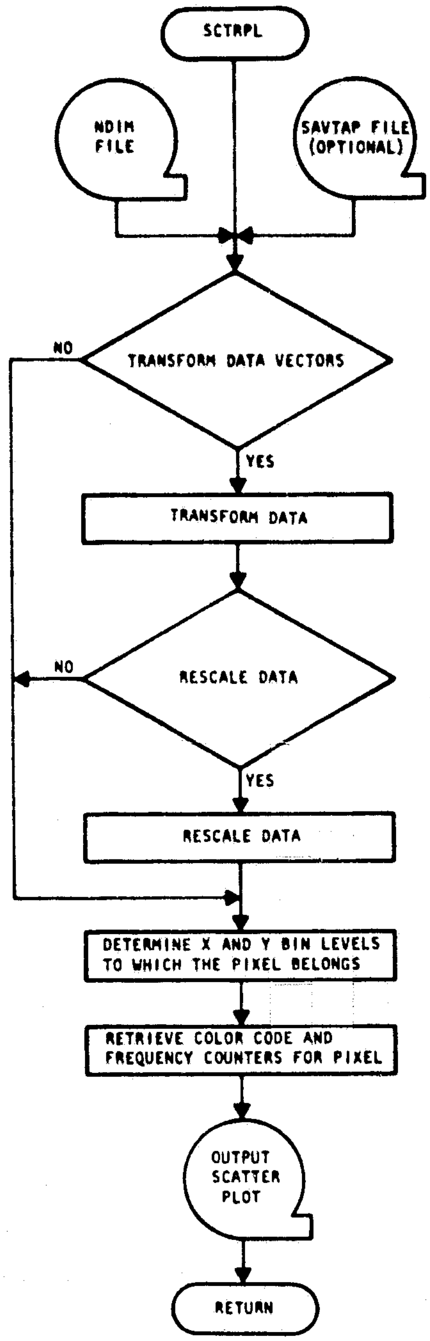
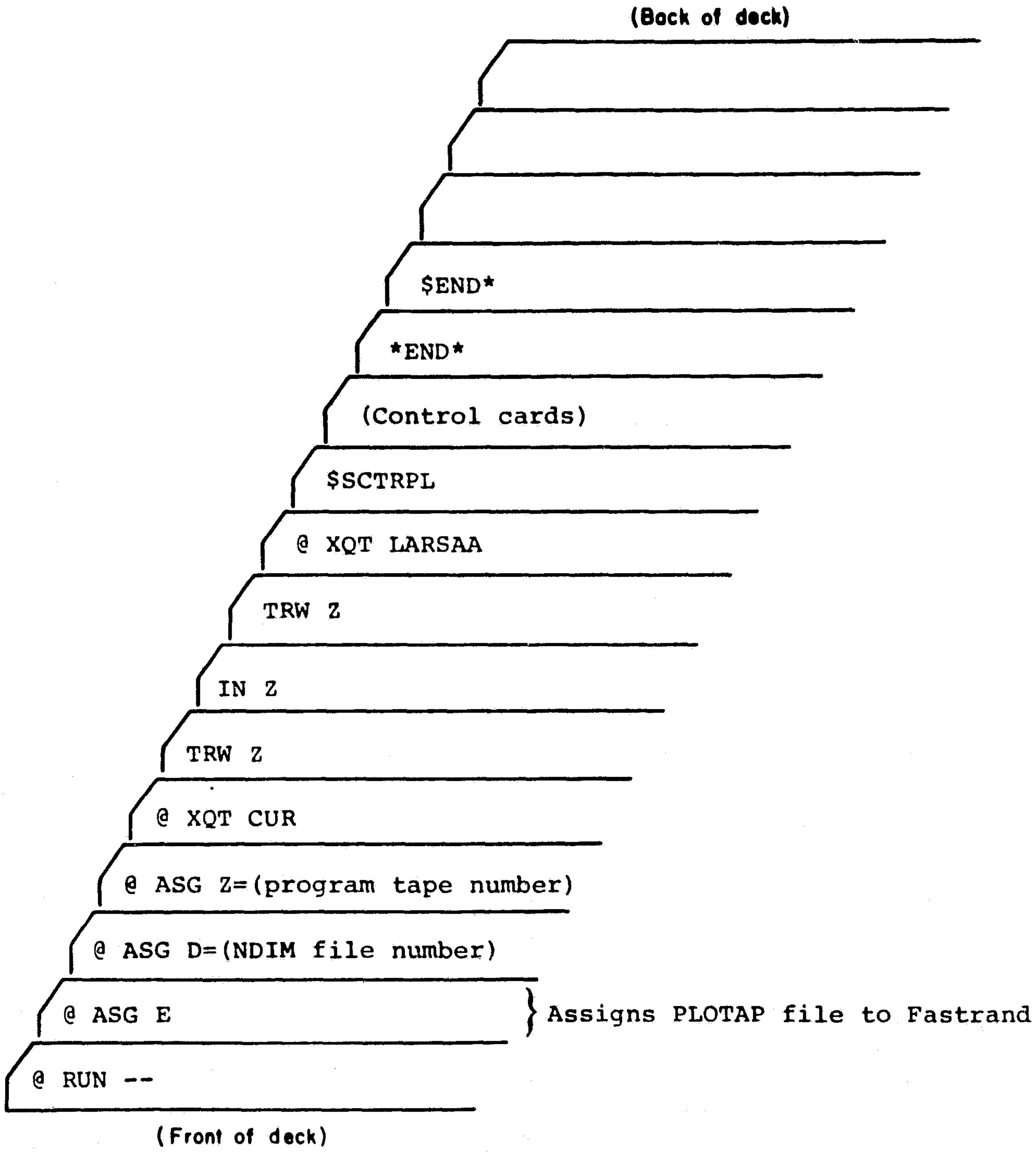
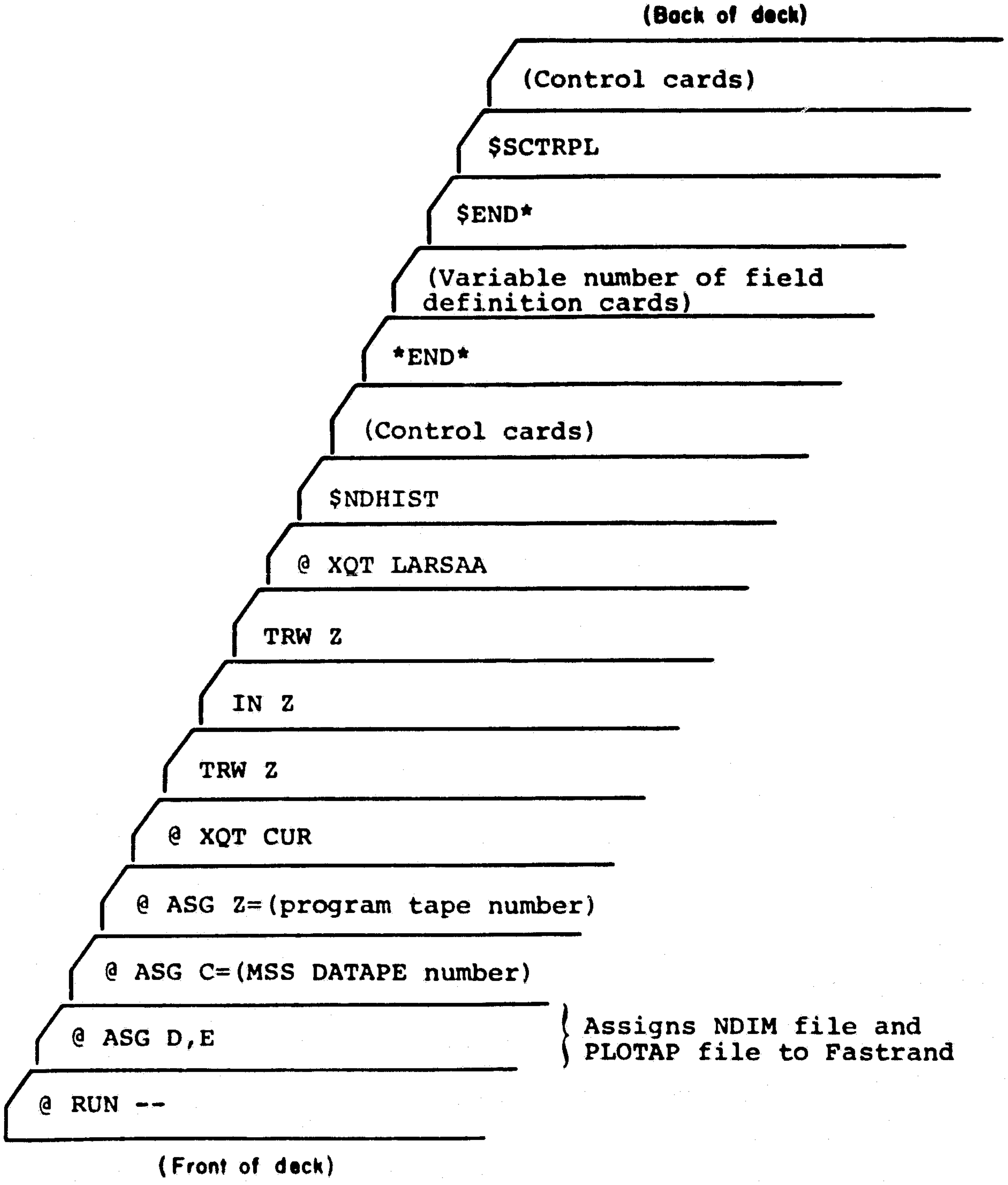


Figure 16-1.– Functional flow chart for the SCTRPL processor.



(a) For independent execution.

Figure 16-2.- Deck setup for the SCTRPL processor.



(b) For execution back to back with NDHIST.

Figure 16-2.– Continued.

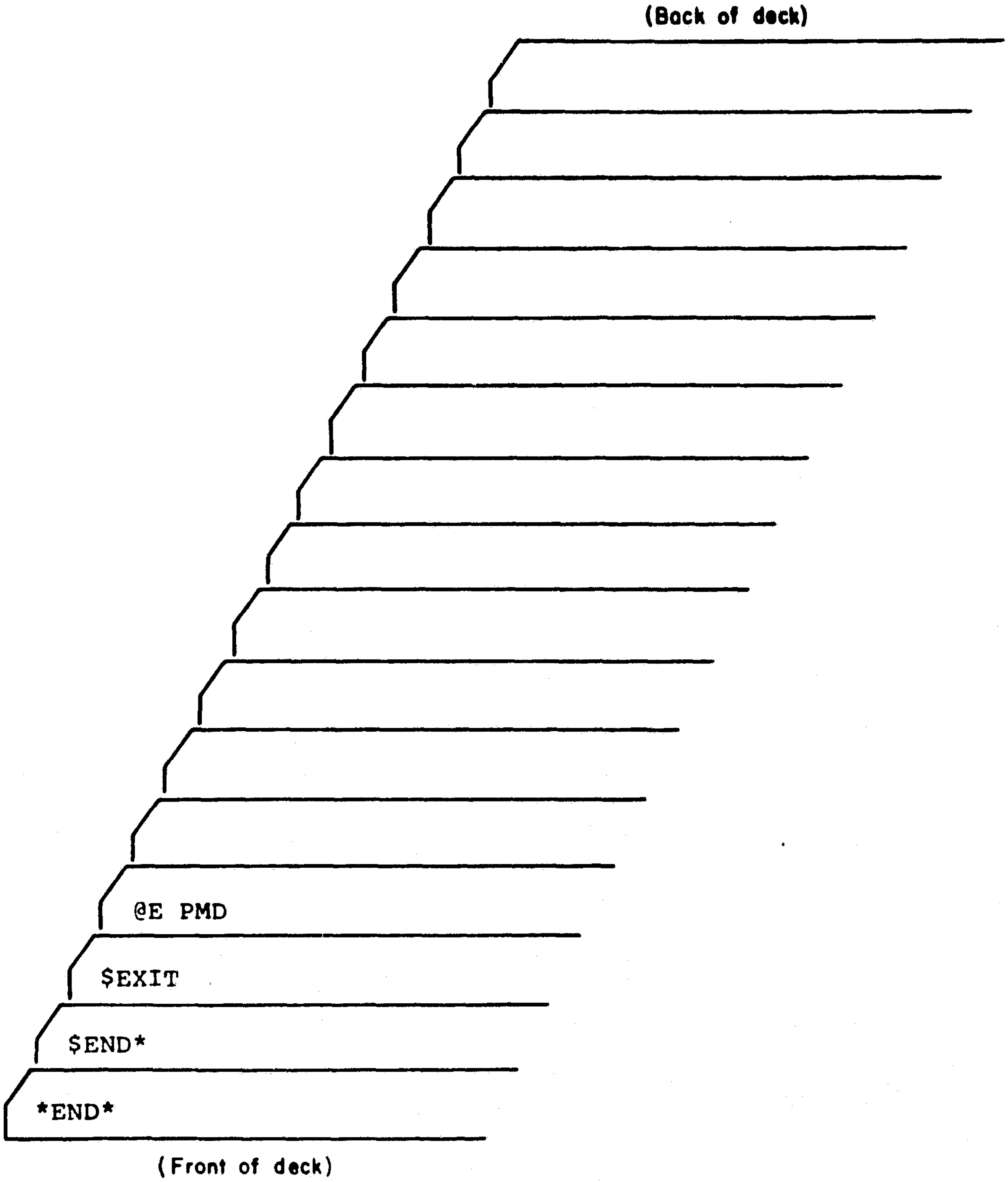


Figure 16-2.– Concluded.

Card	Sample program listing		Comment/command
1	Z RUN L78362,TF,LVIII,1659,C387,C,5,10	WILLS	EXEC 2 run card
2	ASG D=X13345		Assign the previously created NDIM tape
3	ASG Z=X12432		Assign the EOD-LARSYS program tape
4	XQT CUR		Execute Univac complex utility routine
5	TRW Z		Rewind program tape
6	IN Z		Read program tape into the system
7	TRW Z		Rewind program tape
8	XQT LARSAA		Execute EOD-LARSYS
9	$SCTRPL		Execute SCTRPL processor
10	*END*		End of control card input
11	$END*		End of card input to SCTRPL
12	$EXIT		Exit EOD-LARSYS
13	E PMD		Give a core dump if run erre

Figure 16-3.– Sample program listing for the SCTRPL processor using defaults.

Card	Sample program listing	Comment/command
1	Z RUN L78362,TF,H3,1659W,C087,C,10,5 WILLS	EXEC 2 run card
2	ASG C=X19977	Assign MSS DATAPE
3	ASG Z=X20602	Assign EOD-LARSYS program tape
4	ASG D	Assign NDIM to Fastrand
5	ASG E	Assign PLOTAP to Fastrand
6	ASG N	Assign MAPFIL to Fastrand
7	ASG L	Assign TRFORM to Fastrand
8	ASG A	Assign SAVTAP to Fastrand
9	XCT LARSAA	Execute EOD-LARSYS program
10	$ISOCLS	Execute ISOCLS processor (first execution of ISOCLS)
11	STATFILE OUTPUT/UNIT=1,FILE=1	Output SAVTAP to unit A, file 1
12	CHANNEL DATA=1,2,3,4	Channels to use in clustering
13	CLUSTER 20	Maximum of 20 clusters
14	STDMAX 3.6	Splitting threshold value is 3.6
15	*END*	End of control card input
16	CLASSNAME	CLASSNAME card
17	FLD 1 (1,1),(1,1),(196,1),(196,117),(1,117)	Field definition of segment to cluster
18	$END*	End of card input to ISOCLS
19	$ISOCLS	Execute ISOCLS processor (second execution of ISOCLS)
20	COMMENT GENERATE COLOR KEYS	Comment for heading in printout
21	STATFI INPUT/UNIT=1,FILE=1	Use means from unit A, file 1 as starting vectors
22	STATFI OUTPUT/UNIT=1,FILE=2	Output the results of this execution on file 2 of unit A
23	CHANNEL DATA=1,2,3,4	Channels to use in clustering
24	CLUSTER 20	Maximum of 20 clusters
25	STDMAX 3.6	Splitting threshold value is 3.6
26	FORMAT UNIVERSAL	Output MAPFIL in Universal format (mean vector for each corresponding pixel will be output as file 1)
27	CLASSES 2	Two classes will be clustered
28	*END*	End of control cards
29	CLASSNAME	CLASSNAME card
30	FLD 1 (4,4),(1,1),(196,1),(196,117),(1,117)	Field definition of segment to cluster
31	$END*	End of card input for first set of control cards
32	OPTION CLUSTER	The cluster number of each corresponding pixel will be output on MAPFIL as file 2 (third execution of ISOCLS)
33	*END*	End of card input
34	CLASSNAME	CLASSNAME card
35	FLD 1 (4,4),(1,1),(196,1),(196,117),(1,117)	Field definition of segment to cluster
36	$END*	End of all card input to ISOCLS
37	$DATA-TR	Execute DATA-TR processor
38	COMMENT TRANSFORM COLOR KEYS	Comment for heading in printout
39	B-MATRIX CARDS	Initiates the B-matrix
40	2 4 1 2 3 4	
41	.433+00 -.290+00 .632+00 -.562+00 .586+00	B-matrix
42	.600+00 .264+00 .491+00	
43	FORMAT OUTPUT=UNIVERSAL	Output TRFORM in Universal format (transformed data)
44	DATAFIL UNIT=16,FILE=1	Use the mean vectors in file 1 of MAPFIL as data
45	*END*	End of control card input
46	TRFLD (1,1),(1,35),(49,35),(49,50),(1,50)	Field definition of segment to transform (the color keys area in MAPFIL)

Figure 16-4.– Sample program listing and output for the SCTRPL processor using options and executing back to back with ISOCLS, DATA-TR, STAT, and NDHIST.

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Card	Sample program listing		Comment/command
47	$END*		End of card input to DATA-TR
48	$STAT		Execute the STAT processor
49	COMMENT	GENERATE STATS FROM TRANSFORMED COLOR KEYS	Comment
50	STATFILE	UNIT=1,FILE=3	Output statistics (transformed means) in unit A, file 3
51	CHANNEL	1,2	Use these channels in computations
52	DATAFILE	UNIT=14,FILE=1	Use the transformed color keys in file 1 of TRFORM as data
53	*END*		End of control card input
54	CLASSNAME		CLASSNAME card
55	SUBCLASS	U1	
56		(1,1),(5,2),(10,2)	
57	SUBCLASS	U2	
58		(1,1),(16,2),(21,2)	
59	SUBCLASS	U3	
60		(1,1),(27,2),(32,2)	
61	SUBCLASS	U4	Subclasses followed by field definitions for each subclass
62		(1,1),(38,2),(43,2)	
63	SUBCLASS	U5	
64		(1,1),(5,10),(10,10)	
65	SUBCLASS	U6	
66		(1,1),(16,10),(21,10)	
67	SUBCLASS	U7	
68		(1,1),(27,10),(32,10)	
69	$END*		End of card input to STAT
70	$NDHIST		Execute the NDHIST processor
71	COMMENT	HISTOGRAM PLOTTING CHANNELS	Comment
72	MAPFIL	UNIT=16,FILE=2	Use the cluster numbers in file 2 of MAPFIL
73	CHANNEL	PLOT=2,3	Histogram channels 2 and 3
74	DATAFILE	UNIT=3,FILE=1	Process data in unit C, file 1
75	HISFIL	UNIT=4,FILE=1	Output NDIM on unit D
76	*END*		End of control card input
77	FLD 1	(4,4),(1,1),(196,1),(196,117),(1,117)	Field definition of segment to histogram (same field clustered in ISOCLS)
78	$END*		End of card input to NDHIST
79	$SCTRPL		Execute the SCTRPL processor
80	COMMENT	CREATE SCATTER PLOT USING PC OF THE CLUSTER MEANS FOR COLORS	Comment
81	STATFILE	UNIT=1,FILE=3	Means will be extracted from file 3 of unit A and used as the color assignment (transformed means)
82	CHANNEL	1,2	Use channels 1 and 2 from SAVTAP
83	PIXPLT	FREQ	Output a line printer pixel frequency plot
84	PLOTAP	UNIT=7	Output PLOTAP on unit E
85	HISFIL	UNIT=4,FILE=1	Begin processing NDIM of file 1 of unit D
86	*END*		End of control card input
87	$END*		End of card input to SCTRPL processor
88	PMD		Give a core dump if the run errs

Figure 16-4.— Continued.

INPUT TEST FIELDS

FIELD	CLASS	SUBCLASS	VERTICES (SAMPLE,LINE)
1 FLD 1	0		(1, 1) (196, 1) (196, 117) (1, 117)

TOTAL NO. OF VECTORS = 1970
TOTAL NO. OF UNIQUE VECTORS = 339

TIME FOR NUMIST .096 MINUTES

Figure 16-4.— Continued.

HISTOGRAM PLOTTING CHANNELS

```
$SCTRPL

INPUT SUMMARY

COMMEN   CREATE SCATTER PLOT USING PC OF THE CLUSTER MEANS FOR COLORS
STATFI   UNIT=1,FILE=3
CHANNE   1,2
PIXPLT   FREQ
PLOTAP   UNIT=7
HISFIL   UNIT=4,FILE=1
*END*

USER HAS SELECTED THE FOLLOWING OPTIONS :

LINE PRINTER PIXEL FREQ. PLOT
BACK GROUND COLOR FOR SPECTRAL PLOTS WILL BE WHITE
COLOR CODES ARE COMING FROM STAT FILE USING CHANNELS   1  2
```

MEANS

CLUSTER	CH(1)	CH(2)
1	35.00	.00
2	47.00	255.00
3	46.00	.00
4	55.00	4.00
5	36.00	6.00
6	255.00	5.00
7	43.00	10.00

Figure 16-4.— Continued.

```
                              LYNDON B. JOHNSON SPACE CENTER                    09 MAY 77
                                     HOUSTON,TEXAS
CREATE SCATTER PLOT USING PC OF THE CLUSTER MEANS FOR COLORS

                                 INPUT TEST FIELDS
    FIELD          CLASS      SUBCLASS                          VERTICES  (SAMPLE,LINE)
  1  FLD 1           0                                ( 1,   1) ( 196,   1) ( 196, 117) (   1, 117)
                                 SCATTER PLOT TAPE PARAMETERS
                                 NO. OF LINES PER FILE   = 101
                                 NO. OF SAMPLES PER LINE = 101

                                 XLO =   0          YLO =   0
                                 XHI = 100          YHI = 100
                                   COLOR KEYS =   11 LINES
```

Figure 16-4.— Continued.

LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

09 MAY 77

CREATE SCATTER PLOT USING PC OF THE CLUSTER MEANS FOR COLORS

PIXEL FREQUENCY SCATTER PLOT

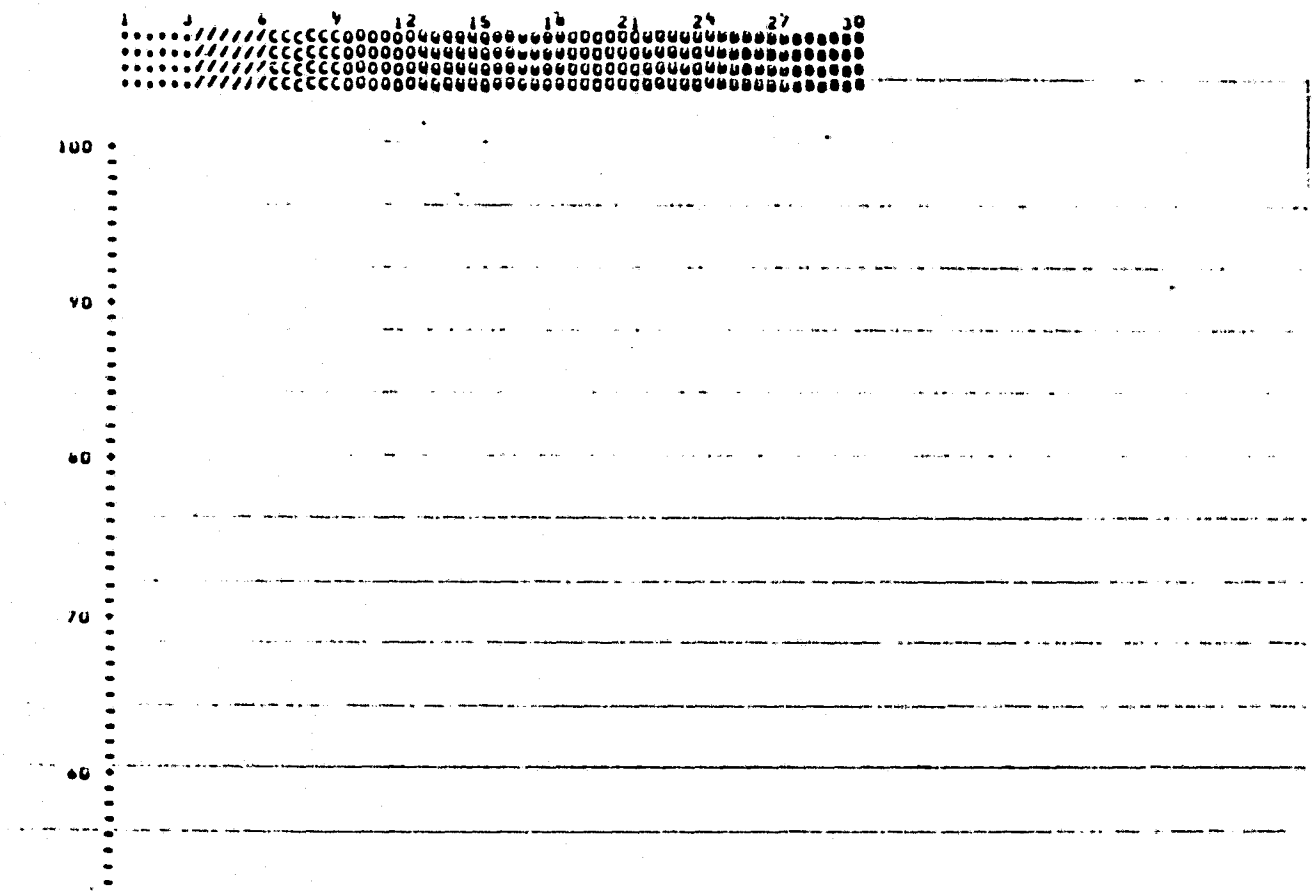

Figure 16-4.— Continued.

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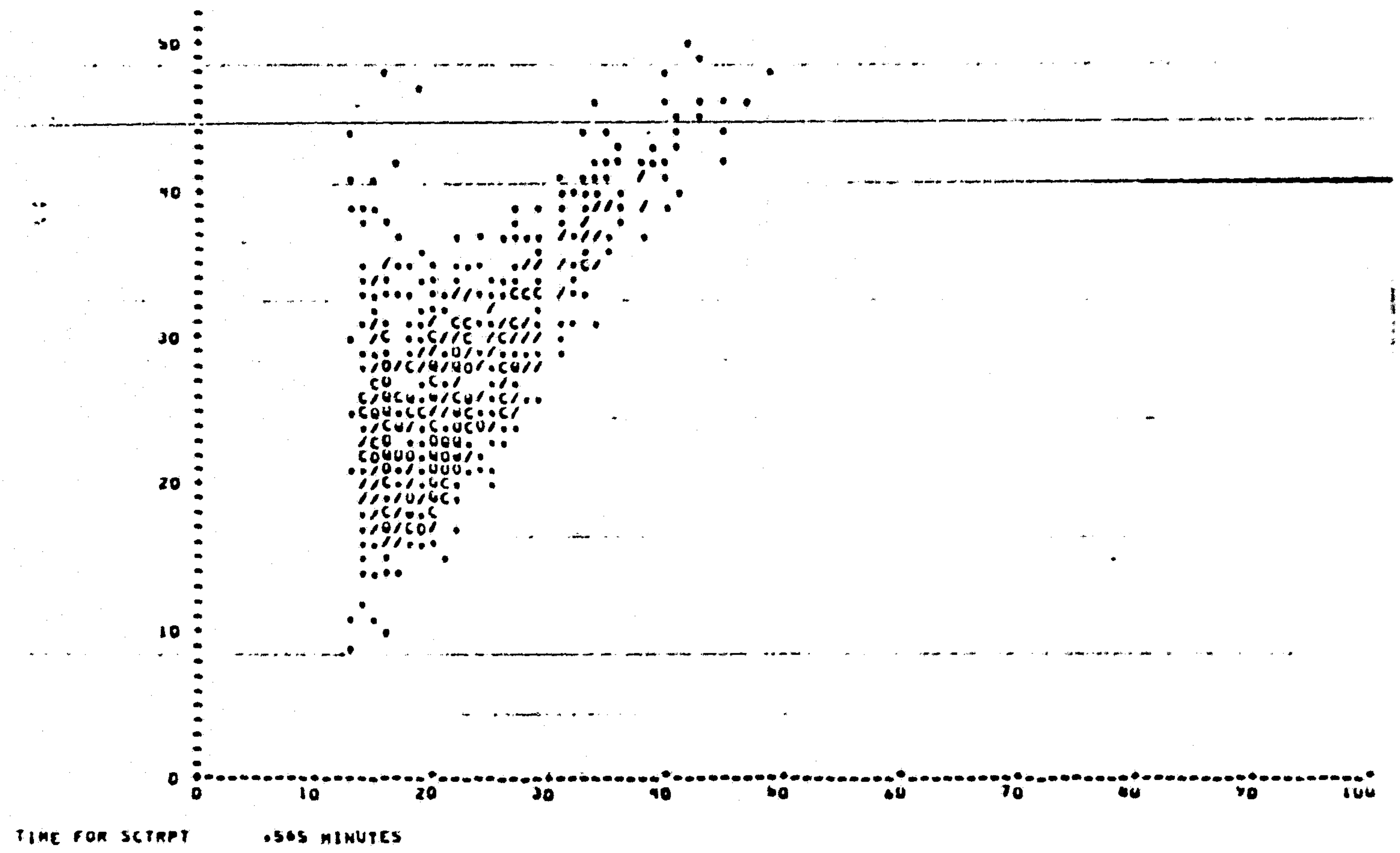

Figure 16-4.— Concluded.

17. SYSTEM RESTRICTIONS

The system is limited in every processor to processing no more than 30 channels of data. The MSS data tape (DATAPE) may have more than 30 channels, but for processing purposes a subset of those channels must be selected via the CHANNELS control card.

A maximum of 60 categories, classes, and subclasses may be processed. However, the maximum number of channels and subclasses may not be processed at one time. The arrays within the system are dimensioned variably according to user requests. The amount of storage available will not accommodate the arrays which are dimensioned number of subclasses by number of channels, if both maximums are used. Restrictions under the STAT, SELECT, and CLASSIFY processors allow the user to compute approximately whether or not the numbers of channels and subclasses selected are acceptable. When core storage requirements are exceeded, a diagnostic message is printed, and the user must reduce his requirements in order to get a successful execution.

18. SYSTEM DIAGNOSTIC MESSAGES

The diagnostic messages listed in this section are printed by utility routines used by more than one processor. Diagnostics which occur only in a given processor are listed in the sections for individual processors.

18.1 CLSCHK ROUTINE

Message	Explanation
a. ** CLSCHK** - REQUESTED SUBCLASS NO. XXX IS NOT AVAILABLE IN INPUT STATISTICS -- REQUEST IGNORED.	Either by the SUBCLASS control card or by default, a subclass number has been requested to be used in classification which is greater than the largest subclass number available in the input training subclasses. The CLASSIFY processor ignores the requested subclass number and deletes it as a possibility for use in classification.
b. ** CLSCHK** - REQUESTED SUBCLASS NO. XXX FOR GROUP NO. XXX IS NOT AVAILABLE IN INPUT STATISTICS FILE.	A subclass number input by either the SUBCLASS or the GROUP control card is greater than the largest training subclass number available. The requested subclass will be deleted and ignored in classification.

18.2 FETCHK (CLSCHK) ROUTINE

Message	Explanation
a. ***** CLSFY/FETCHK --- CHANNEL XXX NOT IN TRAINING DATA --- TRAINING DATA CHANNELS ARE $C_1, C_2, C_3, \cdots C_N$.	A channel requested on the CHANNELS control card or in the B-matrix input for use in classification is not available in the set of channels which was used to obtain training

Message	Explanation
	subclass statistics. The available set of channels in the training statistics is printed out as part of the diagnostic message. Messages b and c are added to this when the B-matrix is not involved (b) and when B-matrix channels are input (c).
b. ***** CHANNEL XX IGNORED (NOT USED) IN CLASSIFICATION.	If the B-matrix is not being input to the CLASSIFY processor (i.e., B-matrix channels are not involved), the requested channel in the previous message will be deleted from the list of channels and ignored by the CLASSIFY processor. In this case, this message is added to the previous diagnostic message.
c. ***** B-MATRIX CHANNELS MUST BE EQUAL TO OR A SUBSET OF AVAILABLE TRAINING DATA CHANNELS --- THE INPUT B-MATRIX CHANNEL SET IS $B_1, B_2, \cdots B_M$. ***** TERMINATING PROGRAM EXECUTION FROM FETCHK *****	If the B-matrix is input to the CLASSIFY processor, the B-matrix channels become the set which is to be used in classification; and if one of the B-matrix channels is not available in the training subclass statistics, the processor cannot continue. In this case, this will be the remainder of error message.

18.3 LAREAD ROUTINE

Message	Explanation
ERROR IN FIELD CARD TERMINATING RUN.	A field description card has an incorrect format. All vertices must be separated by commas and

Message	Explanation
	enclosed in parentheses, and sample and line numbers must be integers. The card which caused the error is printed out with this message.

18.4 GRPSCN ROUTINE

Message	Explanation
///// FROM SUBR. GRPSCN --- CLASS XX INCORRECT --- CLASS XX IGNORED. CARD BEING SCANNED IS CCCC ••• CCCC.	One of the class numbers listed on the GROUP control card has one or more of the following three conditions: (1) not in ascending order, (2) greater than the largest class number allowable (30), or (3) has already been used in another GROUP card. The erroneous GROUP control card is printed as part of the message. The processor will delete the erroneous class number from the list and proceed grouping all other listed classes.

18.5 CRDSTA ROUTINE

Message	Explanation
a. EXCEEDED CORE LIMITS, REDUCE NO. OF SUBCLASSES OR CHANNELS EXITING FROM CRDSTA.	The combination of total number of channels, subclasses, and training fields must be reduced to fit in the internal core storage available to the processor. Total storage is 10 600 locations.
b. ERROR IN TRYING TO POSITION STAT FILE __ IN CRDSTA.	An error occurred in positioning the SAVTAP file, and no statistics were written. Resubmit the run.

18.6 REDSAV ROUTINE

Message	Explanation
a. USER HAS REQUESTED __ CHANNELS, __ SUBCLASSES, AND __ CLASSES. THIS COMBINATION OF STATS WILL NOT FIT IN CORE. PLEASE REDUCE REQUEST.	The fixed amount of internal core storage available to the processor for storing class descriptions, number of subclasses in each class, subclass descriptions, field information, vertices, covariances, means, and working area has been exceeded. The total amount of storage available for the above information is 10 600 locations.[1] Reduce the requested combination.
b. STAT FILE WAS NOT CREATED. EXITING FROM **REDSAV**	An error occurred in positioning the SAVTAP file, and no statistics were written. Resubmit run.
c. ERROR IN POSITIONING STAT FILE TO FILE _____.	Same.

18.7 TAPERD ROUTINE

Message	Explanation
a. A LINE NO. IS LESS THAN OR EQUAL ZERO.	The first line number on the data tape is less than or equal to zero.
b. DATA ORDER INDICATOR = N. DATA MUST BE ORDERED BY PIXEL.	Information from header records indicates data are not ordered samples by channels.
c. ERROR READING FIRST DATA RECORD -- ISTAT = N.	Error occurred while trying to transmit first record from MSS DATAPE.

[1]The equation for computing the required storage is:
STORAGE = 2(number of classes) + (number of subclasses) + 4(number of fields) + 2(total number of vertices for all the fields) + (number of subclasses + 1)[(number of channels)(number of channels + 1)/2] + (number of subclasses)(number of channels).

Message	Explanation
	ISTAT is the status word for the unit trying to read the tape (see message h).
d. ERROR WHILE READING DATA RECORD.	Error occurred while trying to transmit record from MSS DATAPE.
e. FEATURE NUMBERS N AND ABOVE ARE NOT ON DATA TAPE.	User has requested a channel not on MSS DATAPE.
f. FIELD BOUNDARY FOR THIS FIELD DEFINED BEYOND SCOPE OF DATA. THIS FLIGHT LINE CONTAINS N SCAN LINES.	User has requested scan line not on MSS DATAPE.
g. FLDINT MUST BE CALLED TO INITIALIZE PARAMETERS FOR A NEW FIELD.	For every field input there must be a call to FLDINT to reset parameters for positioning the MSS DATAPE.
h. LAST SCAN LINE READ N ISTAT=S.	Gives the number of last scan line read before problem in reading data tape occurred. ISTAT is status word for the unit reading the MSS DATAPE. For example, ISTAT = -1 (transmission not complete) ISTAT = -2 (read through end of file) ISTAT = -3 (device error) ISTAT = -4 (transmission aborted)
i. NO. OF BITS/PIXEL = N. ONLY 8 BITS ACCEPTABLE AT THIS TIME.	According to the header record, the samples on the MSS DATAPE do not equal eight bits. It is assumed that the header record is in error, and execution continues.
j. NO. OF RECORDS PER DATA SET = N. MUST BE LESS THAN OR EQUAL TO 15.	One data set cannot contain more than 15 records.

Message	Explanation
k. ONLY ONE OR LESS RECORDS PER CHANNEL ACCEPTABLE AT THIS TIME.	All of the samples of one channel must be contained within one record.
ℓ. CHECK THE FOLLOWING POSSIBLE ERRORS. 1. DATA TAPE IS NOT IN UNIVERSAL OR LARSYS FORMAT. 2. IF DATA TAPE IS 9-TRACK, THE - ASG - CARD SHOULD HAVE AN - N - OPTION AND A MESSAGE TO OPERATOR SHOULD BE ON 588 FORM. 3. IF DATA TAPE WAS GENERATED ON A MACHINE OTHER THAN THE 1108, THE - ASG - CARD SHOULD HAVE AN - A - OPTION.	The MSS DATAPE must be in LARSYS II, LARSYS III, or Universal format. Additional options must be present on the ASG card if tape is nine-track or was generated on a computer other than the Univac 1108.
m. UNRECOVERABLE ERROR READING HEADER RECORD.	Error occurred while trying to read header record.
n. INTERNAL DIMENSIONS TOO SMALL FOR DATA. NO. OF CHANNELS ON DATA TAPE = XXXXXXX, NO. OF POINTS/CHANNEL = ______________.	The maximum record size of the data record exceeded 6800 words.

18.8 TAPWRT ROUTINE

Message	Explanation
a. ABORTED WHILE IN WRTHDR PART OF SUBROUTINE TAPWRT BECAUSE OF BAD TAPE.	Job aborted while trying to write the header record.
b. DATA SET N WAS BEING WRITTEN WHEN PROGRAM ABORTED.	Job aborted while trying to write data set N in Universal format.

Message	Explanation
c. RECORD N WAS BEING WRITTEN WHEN PROGRAM ABORTED.	Job aborted while trying to write record N in LARSYS II format.
d. USER NSAMP IS TOO LARGE, THUS NSAMP WAS RESET TO 2998.	User requested too much data to be packed into one record. The maximum number of samples per record for Universal format is 2998 samples.

18.9 UNPAK1 ROUTINE

Message	Explanation
***** ERROR FROM SUBR. UNPAK1 --- XX BITS EXCEEDS 32-BIT WORD LENGTH.	The header-unpacking routine UNPAK1 has been sent (via a calling argument) a byte length exceeding 32 bits. The routine rejects any byte length greater than the 32-bit size. The header record of the MSS DATAPE will not unpack when this condition is detected.

APPENDIX A

LARSYS II (OR III) FORMAT FOR AN MSS DATA STORAGE TAPE

APPENDIX A

LARSYS II (OR III) FORMAT FOR AN MSS DATA STORAGE TAPE

This is the second and third versions of the format used in Purdue's LARSYS. The only difference in the second and third version of the format is one word in the header record. That difference is transparent to this system.

There are four types of (physical) records on the Multispectral Scanner Data Storage Tapes. They are:

1. ID record - 200 full words fixed length
2. Data record - variable length
3. End-of-Tape records - 200 full words fixed length
4. End-of-File records - IBM Standard

A Multispectral Scanner Data Storage Tape contains one or more data runs consisting of an ID record, several data records and an End-of-File record. After the last data record on the tape, an End-of-Tape record and two End-of-File records are written on the tape.

For the purposes of this presentation, a 'word' is defined to be 32 bits and a byte to be 8 bits. Further details regarding the physical records follows:

1. <u>ID record</u> (200 full words fixed length)

	FORMAT	DESCRIPTION
ID(1)	Integer	LARS Tape Number (e.g., 1, 17, 102, etc.)
ID(2)	Integer	File number on this tape
ID(3)	Integer	Run number (8 digits aabbbbcc) aa - last 2 digits of the Year data was acquired bbbb - running serial number for the year data was taken cc - uniqueness digits for runs which would otherwise have the same run number
ID(4)	Integer	Continuation Code ID(4) = 0 means the first line of data follows this ID record ID(4) = X means that the data following this ID record is a continuation of a flight line started on tape X
ID(5)	Integer	Number of Data Channels (Spectral bands) on tape (30 maximum)
ID(6)	Integer	Number of Data Samples per channel per scan line
ID(7-10)	Alpha-numeric (4A4)	Flightline Identification (16 characters)

	FORMAT	DESCRIPTION
ID(11)	Integer	Month data was taken
ID(12)	Integer	Day data was taken
ID(13)	Integer	Year data was taken
ID(14)	Alpha-numeric (1A4)	Time data was taken
ID(15)	Integer	Altitude of aircraft
ID(16)	Integer	Ground heading of aircraft
ID(17-19)	Alpha-numeric (3A4)	Date data run was generated on this tape (12 characters)
ID(20-50)	Integer	All zero (to be defined later)
ID(51)	Real	Lower limits in micrometers of first spectral band on tape
ID(52)	Real	Upper limits in micrometers of first spectral band on tape
ID(53)	Real	The suggested value of "C0" calibration pulse
ID(54)	Real	The suggested value of "C1" calibration pulse.
ID(55)	Real	The suggested value of "C2" calibration pulse.
ID(56-200)	Real	Repeat of ID(51-55) for ID(5) channels in order of appearance in Data Records.
ID(51-200)	Real	= 0.0 if Data Channels do not exist.

Data Record:

Each data record will contain one scan line of data from ID(5) (see ID Record) channels. The first half word (2 bytes) of the record will be the record number. The second half word (2 bytes) will be the roll paramater which is a number indicating relative roll of the aircraft for this scan line of data. If the roll parameter is -32.767, the data for the given line does not exist. If the roll parameter has not been calculated, it will be set to 32,767. The fifth byte will be the first data sample from the first channel. The data samples are ordered: Channel_1, Sample_1 - Sample_N; Channel_2, Sample_1- Sample_N; and so on through ID (5), Channels and ID (6) data samples per channel. A data record (scanline) will be ID(5)* ID(6)+4 bytes long.

The data from each channel will be from the field of view of the scanner except the last six bytes. The last six are calibration data in the order of appearance:

1.	C_0	"0" or dark level
2.	VC_0	Variance of C_0
3.	C_1	Calibration source C_1
4.	VC_1	Variance of C_1
5.	C_2	Calibration source C_2
6.	VC_2	Variance of C_2

where C_i = Calibration value i and VC_i = calculated variance of calibration value i.

On good data records all 8-bit data and calibration values will be integers in the range of 0 to 255 with no sign included in the eight bits. A sample data value of 0 to 255 is the result of the 8-bit analog-to-digital conversion which produces the multispectral scanner data tape. With 8-bit A/D conversion, data values range between 0 to 255 with 0 usually indicating low relative irradiance and 255 usually indicating high relative irradiance.

End-of-Tape Record:

The End-of-Tape Record is very similar to the ID Record with 200 full words in the following format.

WORD	FORMAT	DESCRIPTION
ID(1)	Integer	LARS tape number
ID(2)	Integer	File number on this tape
ID(3)	Integer	Set equal to zero
ID(4)	Integer	Continuation Code ID(4) = 0 means end of data ID(4) = X means data in previous file is continued on tape X
ID(5-50)	Integer	All zero (may be defined later)
ID(51-200)	Real	0.0 (may be defined later)

APPENDIX B

UNIVERSAL FORMAT FOR AN MSS DATA STORAGE TAPE

APPENDIX B

UNIVERSAL FORMAT FOR AN MSS DATA STORAGE TAPE

This is an adaptation of the Universal Data Tape Format as defined in the Earth Resources Data Format Control Book, Vol. 1 (ref. 12, section 7).

Ground Rules

The ground rules for the UNIVERSAL format as accepted by all the processors within this system are as follows:

- 8 bits = 1 byte
- The header record is the first record on a tape.
- The header record is fixed length equal to 3060 bytes.
- Data following the header will be arranged by data sets, where a data set is defined as the ancillary data and all of the video data for one scan line for all active channels.
- Data sets will be recorded in variable length physical records, not to exceed 3000 bytes of information per record. Note, since 3000 bytes is not compatible with the word lengths of all computers, the computer generating the tape will add a sufficient number of fill zeros to the end of the data to make the record length divisible by 32, 36, 48, and 60 bits (180 bytes). Therefore, it is possible to have a max physical record length of 3060 bytes, but under no condition will data exceed 3000 bytes.

- Data sets will be packed into consecutive physical records of equal length. Under no condition will a <u>data set</u> begin in the middle of a physical record unless the data set can be completed in that record. If two or more records are needed for the data set, the data set will be divided but under no condition will the data for a <u>video channel</u> begin in the middle of a physical record unless the data for that video channel can be completed in that record. Consequently, data sets which are lengthy will be divided so that the ancillary block and video data from an integral number of channels will be in one record and remaining video data will follow in succeeding records with an integral number of channels per record. Fill zeros will be supplied at the ends of the records as required to satisfy the equal length contraint noted above.
- All data in the header record and ancillary blocks will be in binary.
- The tape format will be as follows:

```
         Header Record
              IRG*

        Ancillary Block
        Video Block          Data Set

              IRG**

        Ancillary Block
        Video Block          Data Set

              IRG
               .
               .
               .
              EOF
```

* IRG = Inter Record Gap - always follows the header record.
** An IRG may appear between the ancillary block and the video block so that the recording of a data set requires more than one physical record; or a physical record may contain two or more data sets, not separated by any IRG. See ground rules above and data set description following for criteria determining the placement of IRG's.

Header Record

Although the header record is 3060 bytes in length, only a portion of the information is pertinent to the system at this time. A general description of the data that is unpacked by the TAPERD routines is as follows:

BYTE NO.	DESCRIPTION	NO. OF BYTES
89	Processing flag 0 = Raw Data 1 = Processed data from computing system	1
90	No. of channels in this job	1
91	No. of bits in a picture element (Must be 8 at this time)	1
92-93	Address of start of video data gives location of start of video within scan.	2
96-97	No. of video elements per scan within a single channel.	2
100-101	Physical record size in bytes This number must be a multiple of 180 bytes.	2
102	No. of channels per physical record This field refers to the second and subsequent records within the recording of a data set. Bytes 1785-1786 give the number of channels of data in the first record of a data set. If no. elements per channel greater than 3K, this field will equal 0.	1

BYTE NO.	DESCRIPTION	NO. OF BYTES
103	No. of physical records per scan per channel. This field is used only when the no. of elements per channel is greater than 3K. Otherwise it is equal to 0.	1
104	No. of records to make a complete data set	1
105-106	Length of ancillary block in bytes	2
107	Data Order Indicator 0 = Video ordered by channel. 1 = Video ordered by pixel	1
108-109	Start Pixel No. Number of the first pixel per scan on this tape referenced to original image. The first pixel in the original image is pixel number one.	2
110-111	Stop Pixel No. Number of the last pixel per scan on this tape referenced to original image.	2
1778	Number of Data Sets per Physical Record	1
1785-1786	Number of channels in the first physical record of the data set	2
1787-1788	Total number of bytes per scan per channel	2

Data Sets

Ancillary Block

- The first block of a data set is the ancillary block.
- The length of the ancillary block is variable, with the number of bytes given in the header record.

- The first word (2 bytes) of every record is a counter giving the number of the physical record within the video data set. This is primarily intended for use in data sets that are greater than 3000 bytes long and therefore require more than one physical record for recording. This word will always equal "1" for the first record of a data set.
- Bytes 3 through 6 will contain the current GMT at the start of this data set recorded in tenths of milliseconds.
- Bytes 7 through 70 will indicate channel status for this scan, one byte per channel, where the LSB = 0 indicates the channel is sync, and the LSB = 1 indicates the channel not in sync.
- 71-72 contain the scan line number. This will be an arbitrary but sequential count for each scan line that appears in the data run.
- Bytes 73 through N will be dependent on whether this job contains raw or processed data. (See byte 89 in the header record.) The value of N will be given in bytes 105 and 106 in the header record and will always be equal to or greater than 70.
- If this job contains raw data, bytes 73 through N will contain the housekeeping data channel from the sensor, if one is available.
- A job containing processed data will, in addition to the 70 bytes of ancillary data already described, contain, at a minimum, the following pieces of information:
  - Latitude of the aircraft or of the center of the image from EREP or satellite in binary.
  - Longitude of the aircraft or of the center of the image from EREP or satellite in binary.

- Altitude in meters recorded in binary.
- Heading in tenths of a degree.
- Ground speed in meters per second.
- Roll - Defined in specific formats, following.
- Pitch - Defined in specific formats, following.
- Yaw - Defined in specific formats, following.
- Sun angle.

The specific formats for each sensor (following in this section) shall provide where this data will appear in the format.

Other parameters may be added, if required, with the length of the ancillary block given in the header.

Video Data

- Following the ancillary block in each data set will be the video data from all of the active channels for one scan. The video data from all of the active channels for one scan will comprise a video block.
- Video blocks within a data run will always contain the same number of video channels.
- Each video block will be the same number of bytes in length. If video data is not available to fill a block, fill zeros will be added to make it the same length as preceding video blocks.
- Video data less than 8 bits per pixel will be packed, right justified, in an 8-bit byte with zeros added to the left.

- Video data greater than 8 bits per pixel will be packed, right justified, in as many 8-bit bytes as necessary to hold the pixel, with zeros added to the left.
- If this tape contains raw data, the PCM sync words associated with the video data, if any, will be included with the video data on this tape. If this tape contains processed data, no sync words will be present.
- Calibration data that is associated with each scan within each channel will be included, if this tape contains raw imagery data, in the same sequence as it appears in the data stream on the flight tape. If this tape contains processed imagery data, the appearance of the calibration data will depend on the specific sensor requirements and will be specified in the respective format following in this document.
- The combined length of the ancillary block and the video block will determine the relationship between data sets and physical records. Some data runs may contain data sets which are so small more than one can be packed into one physical record. Others may contain data sets which will require a whole physical record for each. Still others may contain data sets which are so long that each data set will require two or more physical records.
- Data sets will be packed in physical records depending on the length cf the data set. The ancillary block will always appear in the first physical record per data set. Following the ancillary block, as many complete channels in this data set will be recorded as will fit in up to 3000 bytes. If the data set is too long to be recorded in one physical record, the second and subsequent records will begin with the next active channel in the data set.

- If a video block is divided between more than one record for recording, the number of data channels in the first record may vary from the number of channels in the second and successive records; however, the number of channels in all records following the first per data set will always be the same. The number of channels in the first record and the number in successive records will be given in the header record. In records following the first, if video data is not available so as to allow all records to contain the same number of channels, fill zeros will be added in lieu of the video data in order to make all records the same length. In addition, fill zeros will be added to either the first record or all of the successive records, depending on which is shorter, so as to make all of the records the same length.
- The only arrangement of pixels within a scan of data will be by <u>channel</u>. The Universal format* will be as follows:

- LINE 1
  - CHANNEL 1
    - PIXEL 1
    - PIXEL 2
    - •
    - •
    - •
    - PIXEL N
  - CHANNEL 2
    - PIXEL 1
    - PIXEL 2
    - •
    - •
    - •
    - PIXEL N
  - •
  - •
  - •
  - CHANNEL M
    - PIXEL 1
    - •
    - •
    - •
    - PIXEL N

* If this tape contains raw imagery data, the PCM sync words, if any, that are associated with the data on the flight tape will be included with the data.

LINE 2

CHANNEL 1

PIXEL 1
•
•
•
PIXEL N
•
•
•
CHANNEL M

PIXEL 1
•
•
•
PIXEL N

•
•
•

APPENDIX C

MAPTAP FORMAT

APPENDIX C

MAPTAP FORMAT

The tape, MAPTAP, is output by the processor CLASSIFY. It contains the statistics actually used in classification, the training field, category, class, and subclass information, and the classified data.

Each file consisting of the following types of records:

	4	-	run header records
Repeated for each classified field	1	-	field header record
	N	-	data records
	1	-	end-of-field record
	1	-	end-of-run record
	end-of-file mark		

All records are written with a nonformatted FORTRAN write statement.

RUN Header Record 1

```
WRITE(MAPTAP)(DATE(I),I=1,2),BMFLG,BMCOMB,BMFEAT,NOCLS2,
              NOFLD2,NOSUB2,NOFET2,TOTVT2,NOCAT,VARSZ2,
              (FETVC2(I),I=1,NOFET2)
```

FORTRAN NAME AND DIMENSION	DESCRIPTION
DATE(2)	Date classification was performed
BMFLG	Flag indicating B-MATRIX was used in classification
BMCOMB	No. of linear combinations in B-MATRIX

FORTRAN NAME AND DIMENSION	DESCRIPTION
BMFEAT	No. of channels used in computing the B-MATRIX
NOCLS2	No. of classes
NOFLD2	No. of training fields
NOSUB2	No. of subclasses
NOFET2	No. of channels used in classification
TOTVT2	No. of vertices in training fields
NOCAT	No. of categories
VARSZ2	Size of covariance for each subclass
FETVC2(NOFET2)	Actual channels used in classification

RUN Header Record 2

```
WRITE(MAPTAP)(CATNAM(I),I=1,NOCAT1),(CLSMTX(I),I=1,NOCLS2),
             (SUBNO(I),I=1,NOCLS2),(SUBDES(I),I=1,NOSUB2),
             ((FLDMTX(I,J),I=1,4),J=1,NOFLD2),((VERTEX(I,J),
             I=1,2),J=1,TOTVT2),(SUBCAT(I),I=1,NOSUB2),
             (CLSVC2(I),I=1,NOSUB2),(KATNO (I),I=1,NOCLS2),
             (KEPPTS(I),I=1,NOSUB2)
```

FORTRAN NAME AND DIMENSION	DESCRIPTION
CATNAM(NOCAT1)	Category names (if available) NOCAT1 = no. of categories if CATEGORY classifier was applied NOCAT1 = no. of classes if STANDARD classifier was applied.
CLSMTX(NOCLS2)	Class names

FORTRAN NAME AND DIMENSION	DESCRIPTION
SUBNO(NOCLS2)	No. of subclasses in each class
SUBDES(NOSUB2)	Subclass names
FLDMTX(4,NOFLD2)	Training field information 1 - field name 2 - Class number field belongs to 3 - Subclass number field belongs to 4 - No. of vertices in this field
VERTEX(2,TOTVT2)	Vertices for all the fields; ordered $(\text{sample,line})_1,(\text{sample,line})_2,\ldots (\text{sample,line})_{\text{TOTVT2}}$
SUBCAT(NOSUB2)	Contains the category number to which each corresponding subclass belongs
CLSVC2(NOSUB2)	Contains the class number to which each corresponding subclass belongs
KATNO(NOCLS2)	Contains the category number to which each class belongs
KEPPTS(NOSUB2)	Contains the total number of training field pixels in each subclass

RUN Header Record 3

```
WRITE(MAPTAP)((COVMTX(I,J),I=1,VARSZ2),J=1,NOSUB2)
             ((AVEMTX(I,J),I=1,NOFET2),J=1,NOSUB2)
```

FORTRAN NAME AND DIMENSION	DESCRIPTION
COVMTX(VARSZ2,NOSUB2)	Original or B-transformed covariance matrix for each subclass
AVEMTX(NOFET2,NOSUB2)	Mean vector for each subclass

Run Header Record 4

```
WRITE(MAPTAP)((COVMTX(I,J),I=1,VARSZ2),J=1,NOSUB2),
          (CON(I),I=1,NOSUB2),(DET(I),I=1,NOSUB2)
```

FORTRAN NAME AND DIMENSION	DESCRIPTION
COVMTX(VARSZ2,NOSUB2)	'Modified' Cholesky Factorization of the covariance matrix for each subclass
CON(NOSUB2)	Subclass constants
DET(NOSUB2)	Determinant of covariance matrix for each subclass

Field Header Record

```
WRITE(MAPTAP)(FLDINF(I),I=1,6),PTS,LINES,FLDESC,NC,
          (VERTCS(I),I=1,NC),(VERTCS(I+NC),NC=1,NC)
```

FORTRAN NAME AND DIMENSION	DESCRIPTION
FLDINF(6)	Rectangular coordinates surrounding the field classified. 1 - line start 2 - line stop 3 - line increment 4 - sample start 5 - sample stop 6 - sample increment
PTS	No. of points in the rectangular field defined in FLDINF

FORTRAN NAMES AND DIMENSION	DESCRIPTION
LINES	No. of lines in the rectangular field defined in FLDINF
FLDESC	Name of the classified field
NC	No. of vertices in the classified field
VERTCS(2,NC)	Vertices for the classified field. Vertices are ordered $(\text{sample, line})_1$, $(\text{sample, line})_2$,... $(\text{sample, line})_{NC}$

Data Record

```
WRITE(MAPTAP)ILINE,(IR(I),I=1,PTS),(VR(I),I=1,PTS)
```

FORTRAN NAME AND DIMENSION	DESCRIPTION
ILINE	Line number in reference to the multispectral scanner data tape
IR(PTS)	Subclass number to which each classified data point belongs
VR(PTS)	Liklihood that the point belongs to that subclass

End-of-Field Record

An end-of-field record has the same format as a data record with ILINE=0.

End-of-Run Record

An end-of-run record has the same format as field header record with PTS=0.

APPENDIX D

NDIM FORMAT

APPENDIX D

NDIM FORMAT

The interface tape NDIM is output by the NDHIST processor and read by the SCTRPL processor.

All records are written with a nonformatted Fortran WRITE statement. The header record is always the first file on the tape.

The format of the tape is as follows:

```
             File 1   HEADER RECORD
                      END OF FILE (EOF)

                     (RECORD 1
                     |RECORD 2
                     |RECORD 3 (optional)
        Data file 1 {RECORD 4
                     |RECORD 5
                     |RECORD 6
                     |RECORD 7 (optional)
                     (EOF
              :         :         :
        Data file N   EOF
```

The contents of each record are as follows:

Header Record

TOTMNS	— Total number of means computed
SIZE	— NOFET2/4
NOFET2	— Number of channels to histogram
(FETVC2(I),I=1,NOFET2)	— Actual channels to histogram
NCLRCH	— Number of color code channels
(CLRVEC(I),I=1,NCLRCH)	— Actual color code channels

Record 1

NOFLD2	— Number of fields histogrammed
NOSUB2	— Number of subclasses histogrammed
TOTVT2	— Number of vertices
NOVEC	— Number of unique vectors histogrammed

Record 2

CLSVC2	— Class name
(SUBVC2(I),I=1,NOSUB2)	— Subclass names
((FIELDS(I,J),I=1,4),J=1,NOFLD2)	— Field information
((VERTEX(I,J),I=1,2),J=1,TOTVT2)	— Field vertices

Record 3 (optional)

(MEANS(I),I=1,TOTMNS)	— Mean stats for input fields

Record 4

((PLOT(I,J),I=1,SIZE),J=1,NOVEC)	— Data vectors

Record 5

(ID(I),I=1,NOVEC)	— Class/subclass/field the data vectors belong to

Record 6

(COUNTR(I),I=1,NOVEC)	— Number of occurrences of the data vectors

Record 7 (optional)

(COLOR(I),I=1,NOVEC)	— Color codes extracted from MSS data tape

APPENDIX E

DESCRIPTION OF CLUSTER IMAGE DISPLAY
WITH COLOR KEYS

APPENDIX E

DESCRIPTION OF CLUSTER IMAGE DISPLAY WITH COLOR KEYS

The cluster image data tape output by the ISOCLS processor contains the mean vector to which each corresponding pixel was assigned during clustering and a color key. The color key is an n number of square images of 10 samples by 10 lines in dimensions. A color code square is composed of the mean vector for a given cluster. The color codes are ordered according to cluster number or greenness. The greenness ordering (G) is a function of the four Landsat channels:

$$\left.\begin{aligned} G_{i,N} &= -0.29\mu_{1,N} - 0.56\mu_{2,N} + 0.60\mu_{3,N} + 0.49\mu_{4,N} \\ G_N &= \sum_{i=1}^{M} G_{i,N} \end{aligned}\right\} \quad \text{(E-1)}$$

where

M = number of passes for multiregistered Landsat data

μ_1 = first channel of pass i

μ_2 = second channel of pass i

μ_3 = third channel of pass i

μ_4 = fourth channel of pass i

i = number of pass

N = cluster number

The number of color codes per scan line is computed by

$$K = \frac{\text{number of samples per scan line}}{11} \quad \text{(E-2)}$$

The number of lines required to display the color codes is computed by

$$L = \left[\frac{(\text{number of clusters} - 1)}{K} + 1\right] \times 11 \qquad \text{(E-3)}$$

The clustered field and color key are separated by a scan line of zeros. Each color code square is separated by a 1-by-10 vertical line of zeros.

The data are output in LARSYS II or Universal format (see appendixes A and B, respectively).

The structure of the file is as follows.

HEADER RECORD

IRG[1]

N records – Mean vector for each corresponding pixel

IRG

(N + 1) records – Scan line of zeros

IRG

$$(N+2)\text{ records} - 10\text{ lines}\left\{\begin{array}{ccccccc} & 0 & & 0 & & 0 & \\ & 0 & & 0 & & 0 & \\ \text{color} & 0 & \text{color} & 0 & \cdots & 0 & \text{color} \\ \text{code 1} & \vdots & \text{code 2} & \vdots & & \vdots & \text{code K} \\ & 0 & & 0 & & 0 & \\ \multicolumn{2}{c}{\underbrace{\hspace{6em}}_{\text{10 samples}}} & \multicolumn{2}{c}{\underbrace{\hspace{6em}}} & & \multicolumn{2}{c}{\underbrace{\hspace{6em}}} \end{array}\right.$$

IRG

⋮

(N + L) records – color code (last cluster)

E-O-F[2]

---

[1]Inter-record gap.

[2]End of file.

APPENDIX F

PLOTAP FORMAT

APPENDIX F

PLOTAP FORMAT

The scatter plot image tape, PLOTAP, contains two-axis color-coded spectral plot(s) and is output in the Universal format (appendix B) by the SCTRPL processor. Each file of the multi-file tape contains (1) a single scatter plot image, of which N - 1 channels are color assignments and the Nth channel is the frequency channel, and (2) a color key, unless the color assignment is the radiance values of the output pixel.

The color key is an N number of square images dimensioned 10 samples by 10 lines. A color code square is composed of the colors assigned to a given pixel. Each color code is ordered according to its cluster association; i.e., the color code associated with cluster 1 is output first, followed by the color code associated with cluster 2, etc. The number of color codes per scan line is computed by

$$K = \frac{\text{number of samples per scan line}}{11} \qquad \text{(F-1)}$$

The number of lines required to display the color codes is computed by

$$L = \left[\frac{(\text{number of clusters} - 1)}{K} + 1\right] \times 11 \qquad \text{(F-2)}$$

The scatter plot image and color key are separated by a scan line of zeros. Each color code square is separated by a 1-by-10 vertical line of zeros.

The dimensions of the output tape are user controlled via the control cards SIZE and CHANNELS (see section 16, table 16-1, and section 15, table 15-1, respectively), where

(1) number of samples per scan lines = XSIZ

(2) number of channels = dimensions of color pixel plus the frequency channel

(3) number of scan lines = YSIZ + L

The structure of the file is as follows:

HEADER RECORD

IRG[1]

YSIZ records — scatter plot image

IRG

or

EOF (if color key is omitted)

(YSIZ + 1) records — scan line of zeros

IRG

(YXIZ + 2) records — 10 lines $\left\{ \underbrace{\begin{matrix} \text{color} & 0 \\ \text{code 1} & 0 \\ & 0 \\ & \vdots \\ & 0 \end{matrix}}_{\text{10 samples}} \; \underbrace{\begin{matrix} \text{color} & 0 \\ \text{code 2} & 0 \\ & 0 \\ & \vdots \\ & 0 \end{matrix}} \; \cdots \; \underbrace{\begin{matrix} 0 & \text{color} \\ 0 & \text{code K} \\ 0 & \\ \vdots & \\ 0 & \end{matrix}} \right.$

IRG

⋮

(YXIZ + L) records — color code (last cluster)

E-O-F[2]

---

[1] Inter-record gap.

[2] End of file.

APPENDIX G

PROCESSOR EXECUTION TIMES

APPENDIX G

PROCESSOR EXECUTION TIMES

1. SAMPLE EXECUTION TIMES FOR HIST

TIME CONTRIBUTING FACTORS	RUN 1	RUN 2	RUN 3	RUN 4
1. No. of channels histogrammed	2	3	4	16
2. No. of channels displayed	0	2	0	10
3. No. of fields	1	2	2	5
4. Aprox. no. of pixels	60000	1250	30000	500
5. MSS Image data used	HILL CO.	HILL CO.	HILL CO.	MORTON CO.
5.1 Format of tape	LARSYS 2	LARSYS 2	LARSYS 2	UNIVERSAL
5.2 Channels on tape	28	28	28	16
5.3 Pixels/Scan on tape	381	381	381	600
Execution Time in minutes (includes CPU and I/O time)	.748	1.089	1.232	1.91

Comments

Items 3 and 4 are the major contributors to execution time.

2. SAMPLE EXECUTION TIMES FOR GRAYMAP

TIME CONTRIBUTING FACTORS	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5
1. No. of channels	2	2	5	2	5
2. No. of fields	1	1	4	1	1
3. Pixels/scan	150	170	30	220	200
4. Scan lines	92	140	30	947	300
5. Binlevels input?	NO	YES	NO	NO	NO
6. Default histograms?	NO	NO	NO	NO	YES
7. MSS Image data used	HILL CO.	HILL CO.	C-1	C-1	C-1
7.1 Format of tape	LARSYS 2	LARSYS 2	LARSYS 2	LARSYS 2	LARSYS 2
7.2 Channels on tape	28	28	12	12	12
7.3 Pixels/scan on tape	381	381	228	228	228
Execution time in minutes (includes CPU and I/O time)	1.899	2.215	1.544	3.958	2.827

Comments

Items 1, 3, and 4 are the major contributors to execution time.

3. SAMPLE EXECUTION TIMES FOR STAT

TIME CONTRIBUTING FACTOR	RUN 1	RUN 2	RUN 3	RUN 4
1. No. of classes	6	2	9	1
2. No. of subclasses	6	2	9	1
3. No. of training fields	12	4	23	4
4. No. of channels (Stats)	28	28	12	4
5. No. of channels (hist.)	4	0	0	0
6. Histogram by field?	NO	NO	NO	NO
7. Histogram by class?	YES	NO	NO	NO
8. Spectral plots by class?	YES	NO	NO	NO
9. Print stats by field?	YES	NO	NO	YES
10. Print stats by subclass?	YES	NO	YES	NO
11. Punch stats?	YES	NO	NO	YES
12. MSS image data used	HILL CO.	HILL CO.	LINE C-1	MORTON CO.
12.1 Format of tape	LARSYS 2	LARSYS 2	LARSYS 2	UNIVERSAL
12.2 Channels on tape	28	28	12	16
12.3 Pixels/scan on tape	381	381	228	600
Execution time in minutes (includes CPU and I/O time)	2.076	.67	4.672	1.498

Comments

Item 3 is the major contributor to execution time.

4. SAMPLE EXECUTION TIMES FOR ISOCLS

TIME CONTRIBUTING FACTORS	RUN 1	RUN 2	RUN 3	RUN 4
1. No. of classes	8	2	2	1
2. No. of clusters for each class	4,5,4,4,5, 6,3,3	10,20	11,18	60
3. No. of channels	12	12	16	6
4. No. of fields for each class	4,4,3,4,3, 3,1,1	7,16	15,14	1
5. No. of pixels for each class	1524,1520,1609 2534,1539,891 1247,703	3425,8142	1281,1074	52250
6. No. of iterations for each class	6/class	6/class	10/class	10
7. No. of maps printed	final only	final only	final only	final only
8. MSS Image Data Used	Line C-1	Line C-1	Morton Co.	Line C-1
8.1 Format	LARSYS 2	LARSYS 2	Universal	LARSYS 2
8.2 Channels	12	12	16	12
8.3 Pixels/scan	228	228	600	228
Execution time in minutes (includes CPU and I/O time)	5.427	6.339	4.498	22.0

5. SAMPLE EXECUTION TIMES FOR SELECT

TIME CONTRIBUTING FACTORS	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6	RUN 7
1. No. of subclasses	34	30	9	9	9	9	9
2. No. of channels	12	12	12	12	12	12	12
3. 'Best' request	4	4	4	4	4	4	4
4. Criterion	Ave. Div.	Ave. Div.	Ave. Div.	Trans. Div.	Bhatt. Dist.	Ave. Div.	Trans. Div.
5. Procedure	Without Replacement	Without Replacement	Ex. Search	Ex. Search	Ex. Search	Without Replacement	Without Replacement
Image Data used to get stats	Line C-1	Line C-1	Line C-1	Line C-1	Line C-1	Line C-1	Line C-1
Processor used to get stats	ISOCLS 8 classes clustered	ISOCLS 2 classes clustered	STAT	STAT	STAT	STAT	STAT
Channels selected	11,8,6,10	11,8,6,1	1,6,10,11	1,6,10,11	1,6,10,12	10,6,11,1	9,1,12,6
Execution time in minutes	.73	.558	.365	1.614	2.624	.131	.18

Comments

Runs 3 through 14 show comparable execution times for all procedures combined with each criterion. The same statistics were used in each of these runs.

5. SAMPLE EXECUTION TIMES FOR SELECT
(continued)

TIME CONTRIBUTING FACTORS	RUN 8	RUN 9	RUN 10	RUN 11	RUN 12	RUN 13	RUN 14
1. No. of subclasses	9	9	9	9	9	9	9
2. No. of channels	12	.12	12	12	12	12	12
3. 'Best' request	4	4	4	4	4	4	4
4. Criterion	Bhatt. Dist.	Ave. Div.	Trans. Div.	Bhatt. Dist	Ave. Div.	Trans. Div.	Bhatt Dist.
5. Procedure	Without Replacement	Davidon	Davidon	Davidon	Evaluate Input B-Matrix	Evaluate Input B-Matrix	Evaluate Input B-Matrix
Image Data used to get stats	Line C-1	Line C-1	Line C-1	Line C-1	Line C-1	Line C-1	Line C-1
Processor used to get stats	STAT	STAT	STAT	STAT	STAT	STAT	STAT
Channels selected	9,1,12,6						
Execution time in minutes	.252	1.532	4.738	3.471	.163	.132	.158

6. SAMPLE EXECUTION TIMES FOR CLASSIFY

TIME CONTRIBUTING FACTORS	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6
1. No. of categories	0	2	0	2	0	2
2. No. of subclasses	9	9	60	34	29	29
3. No. channels (or comb.)	4	4	4	4	4	4
4. No. of fields classified	1	1	11	1	29	29
5. No. of pixels classified	209000	209000	11900	209000	2355	2355
6. B-Matrix used?	NO	NO	NO	NO	NO	NO
7. MSS Image data used	C-1	C-1	C-1	C-1	MORTON CO.	MORTON CO.
7.1 Format of tape	LARSYSII	LARSYSII	LARSYSII	LARSYSII	UNIVERSAL	UNIVERSAL
7.2 # Channels on tape	12	12	12	12	16	16
7.3 Pixels/scan on tape	220	220	220	220	600	600
Execution time in minutes (includes CPU and I/O time)	7.21	12.59	3.3	40.14	3.79	3.48

Comments

The major contributors to execution time are items 1, 2, 3, and 5. Runs 1 and 2 show the time differences in the category classifier and the standard classifier.

7. SAMPLE EXECUTION TIMES FOR DISPLAY

TIME CONTRIBUTING FACTORS	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5
1. No. of categories	0	0	0	2	19
2. No. of classes	8	8	8	2	19
3. No. of subclasses	9	9	9	5	19
4. Pixels/scan classified	220	220	220	197	512
5. Lines classified	950	950	950	123	512
6. No. of training or test fields	23	23	23	28	19
7. Per field performance?	YES	YES	YES	YES	YES
8. Thresholding option used	Chi-square	Empirical	none	Input values	none
Image Data Used	Line C-1	Line C-1	Line C-1	Finney Co.	Crop Moisture Index.
Execution time in minutes. (Time includes CPU and I/O)	1.774	3.451	1.709	.564	2.125

Comments

The major contributors to execution time in DISPLAY are items 4, 5, and 8. The empirical thresholding option takes about twice as long as the chi square.

8. SAMPLE EXECUTION TIMES FOR DATA-TR

TIME CONTRIBUTING FACTORS	RUN 1	RUN 2	RUN 3	RUN 4
1. Scaling method	Histograms	Subclass statistics	Subclass statistics	Histograms
2. Dimensions of B-Matrix	3X16	3X16	4X12	4X12
3. Lines output on tape	40	140	50	65
4. Pixels/line output on tape	40	340	40	75
5. Output tape format	LARSYS 2	LARSYS 2	Universal	LARSYS 2
6. Input MSS image data	Hill Co.	Hill Co.	Line C-1	Line C-1
6.1 Format of tape	LARSYS 2	LARSYS 2	LARSYS 2	LARSYS 2
6.2 Channels on tape	28	28	12	12
6.3 Pixels/scan on tape	381	381	228	228
Execution time in minutes (includes CPU and I/O time)	.493	2.241	.591	.538

Comments

Items 3 and 4 are the major contributors to execution time.

APPENDIX H

SAMPLE COMPUTER RUNS FOR EXECUTING PROCESSORS BACK TO BACK

APPENDIX H

SAMPLE COMPUTER RUNS FOR EXECUTING PROCESSORS BACK TO BACK

SAMPLE RUN 1

Run 1 executes CLASSIFY twice and DISPLAY twice. The first execution of CLASSIFY defines two categories for eight classes and nine subclasses of line C-1 statistics. The statistics are input by card deck and will be written on unit A. The second execution of CLASSIFY uses the same statistics, and a standard classification on the nine subclasses is performed. Both executions of CLASSIFY go on the tape assigned to unit B, files 1 and 2. The two executions of DISPLAY print the map for both files.

First execution of CLASSIFY begins, file 1 of MAPTAP

Module STAT deck begins.

```
@Z RUN L73179,TF7,LXI,1659,0619,C,30,10                         MINTER
@W ASG B=V12576
@ ASG C=V03007
@ ASG Z=V01425
@ ASG A
@ XQT CUR
 IN Z
TOC
 TRW Z
@ XQT LARSAA
$CLASSIFY   FILE=1
CHANNELS  1,9,11,12.
CATEGCRY   WHEAT/WHEAT
CATEGCRY     NON-WH/SOYBN1,CORN,OATS,RDCL1,ALFALF,RYE,BRSOIL
MODULE      TRAINING FIELD DECK
NCCLS      8NOSUB     9 NOFEAT 12 NCFLD   23 TOTVRT  115
CHNVEC      1 2 3 4 5 6 7 8 9101112
25-6        1         1         5
VERTICES      69   65   89   65   89   81   69   81   69   65
31-13       1         1         5
VERTICES     141  237  167  237  167  253  141  253  141  237
36-7        1         1         5
VERTICES      59  307   81  307   81  327   59  327   59  307
7-23        1         1         5
VERTICES     135  773  179  773  179  777  135  777  135  773
36-4        2         2         5
VERTICES      33  167   77  167   77  177   33  177   33  167
36-9        2         2         5
VERTICES      45  267   61  267   61  283   45  283   45  267
36-8        2         2         5
VERTICES      21  319   31  319   31  341   21  341   21  319
12-9        2         2         5
VERTICES      13  603   33  603   33  625   13  625   13  603
6-2         3         3         5
VERTICES     145  365  185  365  185  375  145  375  145  365
7-1         3         3         5
VERTICES     135  591  181  591  181  599  135  599  135  591
1-11        3         3         5
VERTICES      63  421   83  421   83  455   63  455   63  421
6-14        4         4         5
VERTICES     177  471  201  471  201  495  177  495  177  471
31-12       4         4         5
VERTICES     134  295  175  295  175  303  134  303  134  295
7-2         4         4         5
VERTICES     203  607  211  607  211  665  203  665  203  607
12-10       4         5         5
VERTICES      17  656   41  656   41  695   17  695   17  656
6-10        5         6         5
VERTICES     139  439  183  439  183  447  139  447  139  439
            5         6         5
VERTICES      69  599   95  599   95  619   69  619   69  599
1-2         5         6         5
VERTICES     175  539  195  539  195  565  175  565  175  539
7-24        6         7         5
VERTICES     131  749  171  749  171  755  131  755  131  749
7-24        6         7         5
```

~~H-3~~

483

```
VERTICES    129  731  177  731  177  737  129  737  129  731
7-22       6          7          5
VERTICES    155  809  183  809  183  817  155  817  155  809
6-8        7          8          5
VERTICES    127  527  155  527  155  569  127  569  127  527
36-1       8          9          5
VERTICES     49   97   85   97   85  115   49  115   49   97
CLSDES     SCYBN1  CORN     OATS     WHEAT    RDCL1    ALFALF  RYE      BRSOIL
SUBNO      1  1  1  2  1  1  1  1
SUBCES     SCYBN1 CORN    OATS    WHT 1   WHT 2  RDCL1   ALFALF RYE     BRSOIL
 NOPTS              1524
MEANS      .16997769+03    .17495210+03    .19327100+03    .19252034+03    .16906102+03
MEANS      .16705184+03    .19051837+03    .17088714+03    .18449409+03    .17286024+03
MEANS      .16242323+03    .18200591+03
COVAR      .65274073+01    .53574336+01    .77711774+01    .39174090+01    .39079335+01
COVAR      .39718175+01    .37877161+01    .42324260+01    .28162174+01    .38085157+01
COVAR      .74806794+01    .82846057+01    .54437276+01    .60450481+01    .13914199+02
COVAR      .64108748+01    .73504820+01    .48119443+01    .54267190+01    .11094011+02
COVAR      .12005847+02    .44160372+01    .48613533+01    .35376967+01    .37425676+01
COVAR      .72447743+01    .70952387+01    .56575742+01    .71964298+01    .86472496+01
COVAR      .56510909+01    .63811547+01    .12734403+02    .11478605+02    .77670125+01
COVAR      .16037155+02    .55520678+01    .70039848+01    .44864996+01    .52108884+01
COVAR      .10100492+02    .87373384+01    .62906535+01    .12599464+02    .12289525+02
COVAR      .57565647+01    .70405760+01    .48323850+01    .53846570+01    .10931712+02
COVAR      .10475405+02    .72931145+01    .13130637+02    .11170218+02    .14280519+02
COVAR      .32038015+01    .23827286+01    .25201620+01    .24244123+01    .61632565+01
COVAR      .97626821+01    .56964213+01    .35008505+01   -.16000719+00    .60677266+01
COVAR      .37219972+02    .89507602+00    .74552272+00    .40220684+00    .95687257+00
COVAR      .27100793+01    .50692931+01    .25373175+01    .17656046+01   -.48881714-01
COVAR      .31544700+01    .14667230+02    .13187752+02
 NOPTS              1520
MEANS      .17085855+03    .17711908+03    .19527697+03    .19497829+03    .17264605+03
MEANS      .16823223+03    .19251316+03    .17830000+03    .19304539+03    .18202960+03
MEANS      .14818816+03    .17376513+03
COVAR      .95184916+01    .69115220+01    .88646785+01    .44309080+01    .37431651+01
COVAR      .34406807+01    .39567691+01    .39940287+01    .22252403+01    .31219773+01
COVAR      .74805143+01    .70079424+01    .42429308+01    .39982355+01    .95862911+01
COVAR      .48544641+01    .49499441+01    .27374775+01    .29444791+01    .57372899+01
COVAR      .58729561+01    .29416254+01    .29717698+01    .19558660+01    .19986400+01
COVAR      .34101902+01    .31941114+01    .32717161+01    .56928900+01    .61907175+01
COVAR      .35284398+01    .38050691+01    .69838051+01    .57373930+01    .39782752+01
COVAR      .95662936+01    .43204476+01    .50512071+01    .27207958+01    .33479249+01
COVAR      .55295736+01    .46932032+01    .36034181+01    .75018433+01    .82316443+01
COVAR      .33267710+01    .38898232+01    .24236578+01    .26517294+01    .51118681+01
COVAR      .48265631+01    .37793995+01    .70766951+01    .65806170+01    .86976087+01
COVAR     -.26494707+01   -.43871340+01   -.16018528+01   -.33224429+01   -.24777953+01
COVAR      .14784744+00   -.78588752+00   -.70749177+01   -.86234251+01   -.30648236+01
COVAR      .53809208+02   -.29094777+01   -.30246799+01   -.17406981+01   -.21301847+01
COVAR     -.22589593+01    .14740524+00   -.87083781+00   -.40789335+01   -.45364016+01
COVAR     -.20127919+01    .23381943+02    .20961917+02
 NOPTS              1609
MEANS      .17872219+03    .18174953+03    .19723617+03    .19657800+03    .17516097+03
MEANS      .17049099+03    .19132753+03    .16950404+03    .18331013+03    .16658421+03
MEANS      .14759664+03    .17001492+03
COVAR      .91161802+01    .66045035+01    .82326256+01    .47323188+01    .41854335+01
COVAR      .39852331+01    .40835606+01    .44924960+01    .27806968+01    .39517793+01
COVAR      .98973590+01    .94961882+01    .63655668+01    .63851358+01    .16003301+02
COVAR      .98305172+01    .91012862+01    .54772540+01    .58472518+01    .13257359+02
COVAR      .15131915+02    .60014969+01    .56218878+01    .38423741+01    .39368126+01
COVAR      .81580653+01    .82277669+01    .62664118+01    .71519314+01    .86648805+01
```

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484

COVAR	.59418314+01	.67607232+01	.12994063+02	.10407219+02	.77813252+01
COVAR	.18960338+02	.37690475+01	.65223772+01	.42861632+01	.58287180+01
COVAR	.93032812+01	.62325851+01	.59841799+01	.16819953+02	.19493933+02
COVAR	.43850395+01	.63043770+01	.45273624+01	.54767917+01	.92168461+01
COVAR	.65711884+01	.61959697+01	.16203484+02	.16684998+02	.18009228+02
COVAR	.31018034+01	-.20718610+01	-.94758997+00	-.36734321+01	-.36875191+01
COVAR	.25831165+01	-.76394983+00	-.15302163+02	-.21300202+02	-.15697665+02
COVAR	.53635088+02	-.18416247+01	-.42929035+01	-.31558881+01	-.41417114+01
COVAR	-.68693179+01	-.25502386+01	-.34632219+01	-.12824065+02	-.14913833+02
COVAR	-.11681605+02	.26076916+02	.24453757+02		
NOPTS	1534				
MEANS	.18260169+03	.18367145+03	.19701956+03	.19534094+03	.17455737+03
MEANS	.17377575+03	.19161604+03	.16234224+03	.17112712+03	.15899739+03
MEANS	.17283181+03	.18596349+03			
COVAR	.78732130+01	.65937731+01	.86930263+01	.46457593+01	.47161491+01
COVAR	.45136421+01	.43315809+01	.49940203+01	.33801512+01	.42900776+01
COVAR	.89083828+01	.99973336+01	.67359941+01	.69500961+01	.15971593+02
COVAR	.83313652+01	.93587592+01	.62085633+01	.66909869+01	.13493629+02
COVAR	.14117976+02	.58906708+01	.63134262+01	.45411082+01	.46626307+01
COVAR	.93328693+01	.93437159+01	.75400166+01	.10912009+02	.12441285+02
COVAR	.83905627+01	.90841533+01	.18665612+02	.18224221+02	.12909707+02
COVAR	.27528586+02	.10326594+02	.11844141+02	.79355423+01	.88170364+01
COVAR	.17647302+02	.17422523+02	.12573303+02	.25320458+02	.26206270+02
COVAR	.15398830+02	.17003709+02	.11564956+02	.12488822+02	.25537658+02
COVAR	.25300785+02	.18426265+02	.36561884+02	.35929882+02	.54530978+02
COVAR	.14244121+02	.14743792+02	.98199905+01	.10013674+02	.21708285+02
COVAR	.22493244+02	.16482673+02	.30686431+02	.28524981+02	.44914107+02
COVAR	.55121075+02	.10988059+02	.11674234+02	.73607926+01	.78108888+01
COVAR	.16864457+02	.17394939+02	.12055119+02	.23843552+02	.22248610+02
COVAR	.34414125+02	.34789681+02	.30148699+02		
NOPTS	1000				
MEANS	.17433800+03	.17444000+03	.19021800+03	.18774300+03	.15613600+03
MEANS	.15355900+03	.17782400+03	.13898700+03	.15473800+03	.13909600+03
MEANS	.15609800+03	.17802300+03			
COVAR	.68706266+01	.80503303+01	.17179579+02	.59722883+01	.10002082+02
COVAR	.86030790+01	.63652312+01	.12261341+02	.87287546+01	.11986938+02
COVAR	.15630663+02	.27509670+02	.20399752+02	.24139091+02	.59919423+02
COVAR	.15201259+02	.29750791+02	.20878016+02	.27081745+02	.60787764+02
COVAR	.72358877+02	.10344833+02	.20139580+02	.14737105+02	.19183952+02
COVAR	.41799736+02	.49925309+02	.36709733+02	.18155550+02	.35931652+02
COVAR	.26728562+02	.34390049+02	.77293060+02	.87182449+02	.62261974+02
COVAR	.11890974+03	.13068625+02	.27502783+02	.20461577+02	.27469135+02
COVAR	.58330963+02	.65934392+02	.48013902+02	.90495089+02	.77933289+02
COVAR	.16157710+02	.33659419+02	.26132204+02	.34770442+02	.75321265+02
COVAR	.86183519+02	.63325221+02	.12094319+03	.99297449+02	.13741620+03
COVAR	.14353229+02	.29527407+02	.22783419+02	.29585772+02	.66133805+02
COVAR	.81671889+02	.59687936+02	.10293521+03	.79427103+02	.10954714+03
COVAR	.11816456+03	.91153413+01	.19363243+02	.14838825+02	.18418329+02
COVAR	.44470342+02	.50277420+02	.35527575+02	.65798097+02	.50066093+02
COVAR	.69153946+02	.66374120+02	.48951422+02		
NOPTS	1539				
MEANS	.19234438+03	.18560949+03	.20049707+03	.20072515+03	.18267511+03
MEANS	.17498570+03	.19682326+03	.18611501+03	.19962053+03	.17815335+03
MEANS	.11384275+03	.14711826+03			
COVAR	.43000513+01	.27386034+01	.42186615+01	.21128412+01	.18470369+01
COVAR	.23645883+01	.19068092+01	.20096312+01	.13551776+01	.21591267+01
COVAR	.40020739+01	.40453467+01	.27818843+01	.27845078+01	.76108952+01
COVAR	.40016751+01	.43084581+01	.27385798+01	.29434026+01	.68653137+01
COVAR	.10031005+02	.26428291+01	.26298962+01	.20345934+01	.20216123+01
COVAR	.41551566+01	.52269907+01	.41364936+01	.39005493+01	.41281670+01

COVAR	.28342116+01	.31259097+01	.65373893+01	.64847400+01	.41971928+01
COVAR	.84698590+01	.26567734+01	.31176464+01	.19793839+01	.24352961+01
COVAR	.44871693+01	.40680440+01	.29523959+01	.56737098+01	.57284728+01
COVAR	.40576895+01	.42328746+01	.28606567+01	.28217591+01	.67202036+01
COVAR	.91874990+01	.52553382+01	.60837826+01	.38612186+01	.11566847+02
COVAR	.49560077+01	.31544186+01	.26165750+01	-.46498452-01	.65008956+01
COVAR	.21281886+02	.82790828+01	-.42543352+01	-.91409824+01	.28502022+02
COVAR	.21452662+03	.34650994+01	.24480321+01	.10881223+01	.31731040+00
COVAR	.36359748+01	.12624578+02	.46594059+01	-.17684862+01	-.47743413+01
COVAR	.16360267+02	.11183525+03	.77383924+02		
NOPTS	891				
MEANS	.17783389+03	.18299663+03	.19925926+03	.19918069+03	.17933109+03
MEANS	.16979461+03	.19422110+03	.18477329+03	.19993603+03	.17645118+03
MEANS	.10342536+03	.14320426+03			
COVAR	.33948499+01	.25994401+01	.50617864+01	.21565959+01	.25345818+01
COVAR	.30394507+01	.20761157+01	.28601596+01	.20531003+01	.31010202+01
COVAR	.34786529+01	.46314531+01	.35623803+01	.37389828+01	.80846391+01
COVAR	.17849468+01	.25869481+01	.18847690+01	.21843453+01	.39456058+01
COVAR	.42240608+01	.18502503+01	.25434419+01	.21325010+01	.21892167+01
COVAR	.36267141+01	.27769228+01	.34712846+01	.45274681+01	.64026065+01
COVAR	.44936745+01	.52252815+01	.89684043+01	.53848447+01	.48782721+01
COVAR	.13406971+02	.39994741+01	.59548405+01	.41357054+01	.49273030+01
COVAR	.77874967+01	.47508909+01	.45006772+01	.11354020+02	.11864442+02
COVAR	.20885106+01	.31060152+01	.23975031+01	.25172587+01	.46931487+01
COVAR	.34219839+01	.30405818+01	.62507169+01	.55648507+01	.56771081+01
COVAR	-.13339378+02	-.18982836+02	-.12817145+02	-.16108408+02	-.25014025+02
COVAR	-.13251863+02	-.13568311+02	-.36761883+02	-.35367139+02	-.14273030+02
COVAR	.15790088+03	-.81828862+01	-.11334143+02	-.84552642+01	-.92627939+01
COVAR	-.15442987+02	-.77197972+01	-.83564496+01	-.21086223+02	-.20130738+02
COVAR	-.87529376+01	.80553464+02	.57769464+02		
NOPTS	1247				
MEANS	.17489414+03	.17520609+03	.19134082+03	.18964956+03	.16111868+03
MEANS	.15829190+03	.18242903+03	.15211467+03	.16892622+03	.15519086+03
MEANS	.15898717+03	.17907939+03			
COVAR	.49165547+01	.35723952+01	.66244251+01	.27712584+01	.28550640+01
COVAR	.33452266+01	.25022005+01	.32616881+01	.21989867+01	.32165788+01
COVAR	.44058318+01	.53944606+01	.37548627+01	.39188325+01	.87499474+01
COVAR	.30541981+01	.43250253+01	.25601463+01	.31882508+01	.51250390+01
COVAR	.56659295+01	.25037174+01	.29187314+01	.23071127+01	.24442102+01
COVAR	.36849948+01	.32887907+01	.36319977+01	.51782802+01	.67187226+01
COVAR	.46591196+01	.52472817+01	.88234575+01	.73300627+01	.54515640+01
COVAR	.14565491+02	.49408197+01	.68539010+01	.43839127+01	.54075115+01
COVAR	.86026636+01	.74982783+01	.56424323+01	.13265289+02	.15126174+02
COVAR	.49800909+01	.65810188+01	.45143542+01	.51375642+01	.84701067+01
COVAR	.71898295+01	.55528820+01	.12795913+02	.13242022+02	.15011698+02
COVAR	-.86492268+00	-.13986376+01	-.50846461+00	-.87849683+00	-.19069832+01
COVAR	-.50989533+00	.96199417-01	-.29078372+01	-.34271111+01	-.16644834+01
COVAR	.17327283+02	-.55900517+00	-.94253881+00	-.69481619+00	-.88467602+00
COVAR	-.14524477+01	-.49831313+00	-.82782820+00	-.23742799+01	-.27734318+01
COVAR	-.16796910+01	.39055138+01	.62561319+01		
NOPTS	703				
MEANS	.16494737+03	.16969132+03	.18957895+03	.18815505+03	.16247937+03
MEANS	.16552632+03	.18784068+03	.15987767+03	.17153627+03	.16476387+03
MEANS	.18318919+03	.19461735+03			
COVAR	.32550607+01	.12615085+01	.33219616+01	.11530214+01	.69605637+00
COVAR	.18139151+01	.62498125+00	.79294274+00	.38161643+00	.13705122+01
COVAR	.11976308+01	.12165587+01	.74486429+00	.76317410+00	.31644600+01
COVAR	.10077973+01	.11926076+01	.57662318+00	.80004498+00	.13071675+01
COVAR	.22610586+01	.78932373+00	.62739054+00	.70775228+00	.48912475+00
COVAR	.61779188+00	.77627830+00	.15472314+01	.77417903+00	.86959226+00

```
                          COVAR      .67491378+00   .58737077+00   .10544532+01   .12339931+01   .72692125+00
                          COVAR      .33097997+01   .46986055+00   .73557160+00   .24606388+00   .65462425+00
                          COVAR      .88500848+00   .11760384+01   .58983275+00   .12109964+01   .21664174+01
                          COVAR      .91205573+00   .82444388+00   .79787074+00   .77740493+00   .12629289+01
                          COVAR      .14620633+01   .10777113+01   .16277674+01   .15384919+01   .36108294+01
                          COVAR      .11438746+01   .82058982+00   .90170940+00   .66720566+00   .73966274+00
                          COVAR      .12279202+01   .13620929+01   .12468237+01   .11263186+01   .18567028+01
                          COVAR      .77661507+01   .16501724+00   .37032174+00   .39511171-01   .39132249+00
                          COVAR      .73212484+00   .66891588+00   .12413628+00   .72520293+00   .84082260+00
                          COVAR      .10505424+01   .40155540+00   .31083594+01
                          *END*
Module STAT deck          ALL        (1,1),(1,1),(220,1),(220,950),(1,950)
is completed.             $END*
-----------------------------------
Second execution of       $CLASSIFY    FILE=2
CLASSIFY begins,          CHANNELS   1,9,11,12
file 2 of MAPTAP;         *END*
standard classi-          ALL        (1,1),(1,1),(220,1),(220,950),(1,950)
fier is used.             $END*
-----------------------------------
First execution           $DISPLAY    FILE=1
of DISPLAY prints         OPTIONS    EMPIRICAL,OUTLINE,PCT
file 1 of MAPTAP.         THRESHOLDS  9*.95
                          *END*
                          $END*
-----------------------------------
Second execution          $DISPLAY    FILE=2
of DISPLAY prints         OPTIONS    CHI-SQUARE,PLOT,OUTLINE,PCT
file 2 of MAPTAP.         THRESHOLDS  9*.95
                          *END*
                          $END*
                          $EXIT
                          @E PMD
```

SAMPLE RUN 2

WILLS

```
@Z RUN L78362,TF7,H4,1659,C087,C,35,5
@ ASG Z=V10394
@ ASG C=X02889
@W ASG A=VC3762
@S ASG B=SAVE
@ XQT CUR
   IN Z
   TRI Z
@ XCT LARSAA
```

Execution of ISOCLS begins. Maximums of 10 and 20 wheat cluster statistics will be written on SAVTAP.

```
$ISOCLS
CHANNELS   1,2,4,9,10,11,12,13,14,15,16,17,18,19,20
DLMIN      3.2
STDMAX     3.2
CLUSTERS   10
CLASSES    2
OPTIONS    STATS
*END*
```

Class WHEAT

```
CLASSNAME WHEAT
WHT6       (1,1),(328,252),(338,251),(340,258),(338,259)
WHT1       (1,1),(278,265),(289,264),(289,266),(279,268)
WHT5       (1,1),(318,265),(328,263),(329,266),(319,267)
WHT3       (1,1),(281,275),(304,271),(305,275),(282,278)
WHT9       (1,1),(320,275),(329,273),(330,281),(322,283)
WHT11      (1,1),(319,284),(327,282),(328,286),(319,287)
WHT2       (1,1),(231,288),(234,286),(239,287),(242,293),(233,296)
WHT8       (1,1),(356,290),(359,290),(362,298),(359,298)
WHT7       (1,1),(315,296),(319,295),(319,298),(316,299)
WHT12      (1,1),(361,308),(366,307),(370,316),(364,316)
WHT4       (1,1),(246,316),(251,316),(254,323),(249,326)
WHT10      (1,1),(370,334),(377,333),(378,337),(372,337)
$END*
CLUSTERS   20
*END*
```

Class NONWH

```
CLASSNAME NON-WH
NONWH15    (1,1),(314,254),(325,252),(327,259),(316,261)
NONWH3     (1,1),(276,260),(282,260),(282,263),(277,264)
NONWH9     (1,1),(283,280),(306,275),(307,278),(283,282)
NONWH6     (1,1),(272,292),(283,290),(284,293),(273,294)
NONWH11    (1,1),(304,303),(316,301),(316,305),(305,307)
NONWH12    (1,1),(319,306),(323,305),(325,313),(321,313)
NONWH5     (1,1),(235,308),(246,307),(248,314),(238,316)
NONWH14    (1,1),(369,309),(373,308),(376,316),(372,317)
NONWH16    (1,1),(355,310),(359,309),(362,317),(358,318)
NONWH1     (1,1),(210,314),(212,312),(220,312),(221,319),(214,320)*
           (211,319)
NONWH18    (1,1),(365,318),(377,316),(378,319),(366,322)
NONWH4     (1,1),(300,319),(304,318),(306,327),(302,327)
NONWH8     (1,1),(213,323),(224,322),(226,329),(216,329)
NONWH13    (1,1),(310,323),(315,323),(317,330),(312,329)
NONWH7     (1,1),(265,333),(271,332),(271,338),(268,338)
NONWH10    (1,1),(295,339),(301,338),(303,344),(298,346)
NONWH2     (1,1),(253,347),(260,346),(262,350),(255,351)
NONWH17    (1,1),(309,352),(318,350),(319,354),(309,356)
$END*
```

Execution of CLASSIFY assigns clusters in class WHEAT to category WHEAT and clusters in class NONWH to category NONWH.	$CLASSIFY	
	CATEGORY	WHEAT/WHEAT
	CATEGORY	NON-WH/NON-WH
	OPTION	STATS
	END	
	SCTION	(1,1),(192,271),(354,247),(389,346),(227,370)
	$END*	
Execution of DISPLAY shows results of previous classification.	$DISPLAY	
	OPTION	PCT,OUTLINE,STATS
	OPTION	CHI SQUARE
	THRESHOLD	30*.99
	END	
	$END*	
	$EXIT	
	@E PMD	

SAMPLE RUN 3

CORBETT

```
@Z RUN L78388,TF,LXI,1659,Q619,5,5
@ ASG Z=V03795
@ ASG C=V07536
@ ASG L=L
@ ASG A=V0C089
@ ASG H
@ XCT CUR
  TRW Z
  IN Z
@ XCT LARSAA
```

Execution of STAT computes statistics for six classes and subclasses and outputs results to SAVTAP.

```
$STAT
CHANNELS   1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16
OPTION     COVAR=C
OPTION     MAXSUB=6
COMMENT    STAT - SELECT - DATA-TR SAMPLE RUN FOR HILL CO. DATA
*END*
CLASSN     WHEAT
SUBCLA     WW1
W1-04      (1,1),(190,42),(204,42),(204,45),(190,45)
W1-C1      (1,1),(319,62),(321,62),(321,81),(319,81)
W1-C2      (1,1),(228,72),(231,72),(231,81),(228,81)
CLASSN     SUMWHT
SUBCLA     SW1
S1-01      (1,1),(258,40),(261,40),(261,57),(258,57)
CLASSN     SUMFAR
SUBCLA     SF1
F1-C5      (1,1),(234,42),(241,42),(241,44),(234,44)
F1-C2      (1,1),(292,62),(294,62),(294,81),(292,81)
F1-01      (1,1),(326,62),(331,62),(331,76),(326,76)
CLASSN     BARLEY
SUBCLA     B1
B1-C2      (1,1),(292,51),(298,51),(298,60),(292,60)
CLASSN     GRASS1
SUBCLA     GRASS1
G1-01      (1,1),(178,50),(190,50),(190,57),(178,57)
CLASSN     STUBBL
SUBCLA     STUBBL
ST-01      (1,1),(305,71),(316,71),(316,79),(305,79)
ST-C2      (1,1),(244,75),(246,75),(246,80),(244,80)
ST-03      (1,1),(165,53),(177,53),(177,59),(165,59)
$END*
```

Execution of SELECT finds best four linear combinations of channels used in STAT and outputs B-matrix on BMFILE.

```
$SELECT
PROCEDURE  3
CRITERION  3
BEST       4
*END*
$END*
```

Execution of DATA-TR transforms data within the input fields and outputs on two scratch files.

```
$DATA-TR
MODULE     FILE
B-MATRIX   FILE
OPTION     T
SUBCLASS   1,3,5,6
*END*
1          (1,1),(5,10),(75,19),(223,140),17,55)
2          (2,3),(1,1),(320,17),(180,138),(16,49)
$END*
$EXIT
@E PMD
```

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SAMPLE RUN 4

The CLASSIFY and DISPLAY processors are being executed back to back, thereby allowing the user to classify the data and apply thresholding to the classification results in one execution. The B-Matrix deck being input to CLASSIFY was punched by a previous run of SELECT; the threshold values being input to DISPLAY will be the actual threshold values used in thresholding the classified data.

```
@Z RUN L78362,TF7,H4,1659,C087,C,15,500                          WILLS
@ ASG Z=V10394
@ ASG A=V10716
@ ASG C=V03662
@ ASG B=SAVE
@ ASG H
@ XCT CUR
  TRW Z
  IN Z
  TRI Z
@ XCT LARSAA
```

Execution of CLASSIFY begins.

```
$CLASSIFY
OPTION    STATS
CHANNEL   1,6,10,11
```

B-matrix deck

```
B-MATRIX    CARDS
COMB  4FEAT 12VEC 1 2 3 4 5 6 7 8 9101112
BMTRX   .96588873+00  -.23760400-02   .10097707+00   .71114451-01   .65424752+00
BMTRX   .36120504-01  -.85148202-01   .10229724-01   .14111144+00  -.57050236-01
BMTRX   .58947240-01  -.10160400+00   .70889892+00  -.87198596-01   .10700799+00
BMTRX  -.80145527-01   .16060054+00   .40859264+00   .23366997+00  -.53755232-01
BMTRX   .26256476+00   .10868890+01  -.24610269+00   .15948236+00  -.29002942+00
BMTRX   .71158842+00   .10462217+00  -.28074330+00  -.46429954+00   .13432883+00
BMTRX   .63883948+00   .12578271+00   .10124494+00  -.39485252+00   .12487580+01
BMTRX  -.40717633-03  -.27643728+00  -.32273288+00   .45475551+00   .40844041+00
BMTRX  -.21339156+00   .22700078-01  -.21491076+00   .81542703+00  -.36264534+00
BMTRX   .34058147-02  -.48987948+00   .10589304+01
*END*
FIELD      (1,1),(1,1),(220,1),(220,950),(1,950)
$END*
```

Execution of DISPLAY begins.

```
$DISPLAY
OPTION    PCT,CUTLINE,STATS
OPTION    THRESHOLD VALUES
THRESHOLD 10.40,11.80,11.00,10.20,15.40,10.40,10.40,11.00,10.60
*END*
$END*
$EXIT
@E PMD
```

SAMPLE RUN 5

The STAT, SELECT, CLASSIFY, and DISPLAY processors are being executed back to back, thereby allowing the user to do the following:

1. Obtain statistics from training fields (STAT).
2. Select the best of four channels from MSS DATAPE (SELECT).
3. Classify the MSS data (CLASSIFY).
4. Display the classification results six times exercising the chi-square, empirical, and no thresholding options for both the training and the test fields.

```
                              @Z RUN L78362,TF7,H4,1659,C087,C,30,500            WILLS
                              @N MSG     TAPES 3
                              @ ASG C=V03662
                              @ ASG B=V14443
                              @ ASG A=V10680
                              @ ASG Z=V14837
                              @ ASG H
                              @ XCT CUR
                                TRW Z
                                IN Z
                                TRW Z
                              @ XCT LARSAA
Execution of STAT             $STAT
begins.                       OPTION     MAXSUB=23
                              CHANNEL    1,2,3,4,5,6,7,8,9,10,11,12
                              COMMENT        STAT-SELECT-CLASSIFY(STANDARD)-DISPLAY
                              *END*
Input of training             CLASSN     SOYBN1
fields begins.                SUBCLA     SOYBN1
                              25-6       (1,1),(69,65),(89,65),(89,81),(69,81)
                              31-13      (1,1),(141,237),(167,237),(167,253),(141,253)
                              36-7       (1,1),(59,307),(81,307),(81,327),(59,327)
                              7-23       (1,1),(135,773),(179,773),(179,777),(135,777)
                              CLASSNAME  CORN
                              SUBCLA     CORN
                              36-4       (1,1),(33,167),(77,167),(77,177),(33,177)
                              36-9       (1,1),(45,267),(61,267),(61,283),(45,283)
                              36-8       (1,1),(21,319),(31,319),(31,341),(21,341)
                              12-9       (1,1),(13,603),(33,603),(33,625),(13,625)
                              CLASSNAME  OATS
                              SUBCLA     OATS
                              6-2        (1,1),(145,365),(185,365),(185,375),(145,375)
                              7-1        (1,1),(135,591),(181,591),(181,599),(135,599)
                              1-11       (1,1),(63,421),(83,421),(83,455),(63,455)
                              CLASSNAME  WHEAT
                              SUBCLA     WHT 1
                              6-14       (1,1),(177,471),(201,471),(201,495),(177,495)
                              31-12      (1,1),(134,295),(175,295),(175,303),(134,303)
                              7-2        (1,1),(203,607),(211,607),(211,665),(203,665)
                              SUBCLA     WHT 2
                              12-10      (1,1),(17,656),(41,656),(41,695),(17,695)
                              CLASSNAME  RDCL1
                              SUBCLA     RDCL1
                              6-10       (1,1),(139,439),(183,439),(183,447),(139,447)
                                         (1,1),(69,599),(95,599),(95,619),(69,619)
                              1-2        (1,1),(175,539),(195,539),(195,565),(175,565)
                              CLASSN     ALFALF
                              SUBCLA     ALFALF
                              7-24       (1,1),(131,749),(171,749),(171,755),(131,755)
                              7-24       (1,1),(129,731),(177,731),(177,737),(129,737)
                              7-22       (1,1),(155,809),(183,809),(183,817),(155,817)
                              CLASSN     RYE
                              SUBCLA     RYE
                              6-8        (1,1),(127,527),(155,527),(155,569),(127,569)
                              CLASSN     BRSOIL
                              SUBCLA     BRSOIL
End of training               36-1       (1,1),(49,97),(85,97),(85,115),(49,115)
field input.                  $END*
```

Execution of SELECT begins.	$SELECT	
	BEST	4
	OPTIONS	STATS
	COMMENT	STAT-SELECT-CLASSIFY(STANDARD)-DISPLAY
	END	
	$END*	
Execution of CLASSIFY begins.	$CLASSIFY	
	OPTIONS	STATS
	COMMENT	STAT-SELECT-CLASSIFY(STANDARD)-DISPLAY
	END	
	F-CU	(1,1),(1,1),(220,1),(220,950),(1,950)
	$END*	
	$END*	
Execution of DISPLAY begins.	$DISPLAY	
	COMMENT	TRAINING FIELDS
	OPTIONS	PCT,CUTLINE
Chi-square option	OPTIONS	CHI SQUARE
	OPTIONS	STATS
	THRESHOLD	9*.98
	END	
	$END*	
	$DISPLAY	
	OPTIONS	PCT,CUTLINE
Empirical option	OPTIONS	EMPIRICAL
	THRESHOLD	9*.98
	END	
	$END*	
	$DISPLAY	
Without thresholding	OPTIONS	PCT,CUTLINE
	END	
	$END*	
	$DISPLAY	
	COMMENT	TEST FIELDS
	OPTIONS	PCT,CUTLINE
	OPTIONS	STATS
Chi-square option	OPTIONS	CHI SQUARE
	THRESHOLD	9*.98
	END	
Input of test fields begins.	SUBCLASS	SOYBN1
	12-7	(1,1),(51,647),(87,647),(87,699),(51,699)
	12-2	(1,1),(93,647),(111,647),(111,675),(93,675)
	12-2	(1,1),(33,705),(63,705),(63,797),(33,797)
	7-23	(1,1),(121,759),(197,759),(197,785),(121,785)
	SUBCLASS	CORN
	12-9	(1,1),(3,589),(43,589),(43,643),(3,643)
	SUBCLASS	OATS
	7-1	(1,1),(121,583),(193,583),(193,605),(121,605)
	SUBCLASS	WHT 1
	7-2	(1,1),(203,581),(211,581),(211,689),(203,689)
	12-10	(1,1),(3,649),(43,649),(43,699),(3,699)
	SUBCLASS	RDCL1
	12-8	(1,1),(49,589),(109,589),(109,633),(49,633)
	7-29	(1,1),(121,613),(183,613),(183,619),(121,619)
	7-28	(1,1),(123,629),(191,629),(191,637),(123,637)
		(1,1),(127,675),(195,675),(195,695),(127,695)
	SUBCLASS	ALFALF
	7-24	(1,1),(121,729),(195,729),(195,737),(121,737)
End of test field input.	7-24	(1,1),(121,745),(195,745),(195,758),(121,758)
	$END*	

Second execution of DISPLAY begins.	$DISPLAY	
	OPTIONS	PCT,OUTLINE
	THRESHOLD	9*.98
Empirical option	OPTIONS	EMPIRICAL
	COMMENT	TEST FIELDS
	END	
Test field input begins.	SUBCLASS	SOYBN1
	12-7	(1,1),(51,647),(87,647),(87,699),(51,699)
	12-2	(1,1),(93,647),(111,647),(111,675),(93,675)
	12-2	(1,1),(33,705),(63,705),(63,797),(33,797)
	7-23	(1,1),(121,759),(197,759),(197,785),(121,785)
	SUBCLASS	CORN
	12-9	(1,1),(3,589),(43,589),(43,643),(3,643)
	SUBCLASS	OATS
	7-1	(1,1),(121,583),(193,583),(193,605),(121,605)
	SUBCLASS	WHT 1
	7-2	(1,1),(203,581),(211,581),(211,689),(203,689)
	12-10	(1,1),(3,649),(43,649),(43,699),(3,699)
	SUBCLASS	RDCL1
	12-8	(1,1),(49,589),(109,589),(109,633),(49,633)
	7-29	(1,1),(121,613),(183,613),(183,619),(121,619)
	7-28	(1,1),(123,629),(191,629),(191,637),(123,637)
		(1,1),(127,675),(195,675),(195,695),(127,695)
	SUBCLASS	ALFALF
	7-24	(1,1),(121,729),(195,729),(195,737),(121,737)
	7-24	(1,1),(121,745),(195,745),(195,758),(121,758)
	$END*	
Third execution of DISPLAY without thresholding.	$DISPLAY	
	COMMENT	TEST FIELDS
	END	
Test field input begins.	SUBCLASS	SOYBN1
	12-7	(1,1),(51,647),(87,647),(87,699),(51,699)
	12-2	(1,1),(93,647),(111,647),(111,675),(93,675)
	12-2	(1,1),(33,705),(63,705),(63,797),(33,797)
	7-23	(1,1),(121,759),(197,759),(197,785),(121,785)
	SUBCLASS	CORN
	12-9	(1,1),(3,589),(43,589),(43,643),(3,643)
	SUBCLASS	OATS
	7-1	(1,1),(121,583),(193,583),(193,605),(121,605)
	SUBCLASS	WHT 1
	7-2	(1,1),(203,581),(211,581),(211,689),(203,689)
	12-10	(1,1),(3,649),(43,649),(43,699),(3,699)
	SUBCLASS	RDCL1
	12-8	(1,1),(49,589),(109,589),(109,633),(49,633)
	7-29	(1,1),(121,613),(183,613),(183,619),(121,619)
	7-28	(1,1),(123,629),(191,629),(191,637),(123,637)
		(1,1),(127,675),(195,675),(195,695),(127,695)
	SUBCLASS	ALFALF
	7-24	(1,1),(121,729),(195,729),(195,737),(121,737)
End of test field input.	7-24	(1,1),(121,745),(195,745),(195,758),(121,758)
	$END*	
	$EXIT	
	8 PMD	

SAMPLE RUN 6

This run demonstrates the use of the DATAFILE control card in accessing several files of a data tape in back-to-back executions of HIST.

```
@Z RUN L7R362,TF7,H4,1659,C087,C,5,500                    WILLS
@ ASG C=V15495
@ ASG Z=V1C49R
@ XCT CUR
  TRW Z
  IN Z
  TRW Z
@ XCT LARSAA
```

Histogram channel 1 from file 1 of the MSS DATAPE.

```
$HIST
CHANNEL    1
SIZE       XHIGH=100
DISPLAY    1
DATAFILE   1
*END*
FILE1      (1,1),(1,1),(11,1),(11,4),(1,4)
$END*
```

Histogram channel 1 from file 4 of the MSS DATAPE.

```
$HIST
CHANNEL    1
SIZE       XHIGH=100
DISPLAY    1
DATAFILE   4
*END*
FILE4      (1,1),(1,1),(55,1),(55,238),(1,238)
$END*
```

Histogram channel 1 from file 2 of the MSS DATAPE.

```
$HIST
CHANNEL    1
SIZE       XHIGH=100
DISPLAY    1
DATAFILE   2
*END*
FLIE2      (1,1),(1,1),(11,1),(11,31),(1,31)
$END*
```

Histogram channel 1 from file 5 of the MSS DATAPE.

```
$HIST
CHANNEL    1
SIZE       XHIGH=100
DISPLAY    1
DATAFILE   5
*END*
FILE5      (1,1),(1,1),(40,1),(40,23),(1,23)
$END*
```

Histogram channel 1 from file 3 of the MSS DATAPE.

```
$HIST
CHANNEL    1
SIZE       XHIGH=100
DISPLAY    1
DATAFILE   3
*END*
FILE3      (1,1),(1,1),(5,1),(5,12),(1,12)
$END*
@ FIN
```

APPENDIX I

REFERENCES

APPENDIX I

REFERENCES

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